LONG-TERM EXPERIMENTAL INVESTIGATION OF TIMBER COMPOSITE BEAMS IN CYCLIC HUMIDITY CONDITIONS

Mulugheta Hailu¹, Rijun Shrestha², Keith Crews³

ABSTRACT: A long term laboratory investigation on two six-meter-span timber composite beams was started from March 2012 at the University of Technology Sydney. These timber composites were made of laminated veneer lumber (LVL). The web and the flanges of the composite timber section were connected using screw-gluing technique. The specimens have been under sustained loads of (2.1 kPa) and the environmental conditions was cyclically alternated between normal and very humid conditions whilst the temperature remained quasi constant (22 °C) – typical cycle duration was six to eight weeks. With regard to EC 5, the environmental conditions can be classified as service class 3 where the relative humidity of the air exceeds 85% and the moisture content of the timber samples reaches 20%. During the test, the mid-span deflection, moisture content of the timber beams and relative humidity of the air were continuously monitored. The paper presents the results and observations of the long-term test to-date and the test is continuing.

KEYWORDS: Timber composites, mechano-sorptive creep, gross creep factor

1 INTRODUCTION

Several studies undertaken in Canada, the USA, Australia and New Zealand have highlighted the lack of timber used in non-residential buildings. In this regard, since January 2009, a research program has been undertaken at the University of Technology Sydney (UTS) through the Structural Timber Innovation Company (STIC) on long span timber floors (6m and 8m span) to include the static, dynamic and long term behaviour [1, 2].

Design of timber composite systems requires verification of serviceability and ultimate limit states. With the increasing trend in long span and lightweight constructions, design of these floors may be governed by serviceability limit states and deflection under long-term load is one of the serviceability criteria that need to be addressed.

The long-term behaviours of timber composite structures depend on a number of phenomena taking place in its components. Phenomena such as creep, shrinkage or swelling effects in timber and creep in connection affect the strength, stiffness and deflection behaviour of timber composites. Creep due to variation in the moisture (mechano-sorptive creep) plays a major role in the long-term behaviour of timber composite floors. Factors such as size, surface properties, loading type, length of environmental cycle, etc. also indirectly affect the long-term behaviour of composite floors [3].

Development of timber only composite sections to fulfil both strength and serviceability limit state design for long span floor and their behaviour under short term and dynamic loads has been reported in [1, 2]. This paper presents the results of on-going long-term experimental investigation on two of those proposed long span timber beams (6.0 meter span) in cyclic humidity conditions.

2 EXPERIMENTAL INVESTIGATION

Timber composite beams with a span of 6 m were fabricated using laminated veneer lumber (LVL) with different stress grades. The interlayer connections are with screw-gluing technique using polyurethane glue (PUR) adhesive. The web and the flanges of the composite timber section were connected using screw-gluing technique. The glue allowed for full composite action between the web and the flanges while the screw facilitated full contact between the web and the flanges during the setting of the glue.
The typical cross section of the beams under investigation is shown in Figure 1.

The timber beams were subjected to four-point bending under service load to determine their bending stiffness before the commencement of the long-term test. The apparent bending stiffness (EI) was 4.21 and 4.24 Nmm² for beams L6-01 and L6-03, respectively [1].

![Figure 1: Typical cross section of the composite beams](image)

These beams were placed in a humidity chamber. The beams were simply supported as shown in Figure 2 and a sustained load was applied using lead bars evenly spaced on the top of the beams. The serviceability loads applied are equivalent to a uniformly distributed load of 2.1 Kpa. Instantaneous deflections immediately after the application of the service load were recorded and are given in Table 1.

![Figure 2: long-term test set up](image)

During the long term test, the mid-span deflection, moisture content of the timber beams and relative humidity of the air were continuously monitored.

![Figure 3: Mid span deflection, relative humidity time graph](image)

### Table 1: Instantaneous deflection of the beams

<table>
<thead>
<tr>
<th>Beam</th>
<th>(mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L6-01</td>
<td>6.5</td>
</tr>
<tr>
<td>L6-03</td>
<td>6.4</td>
</tr>
</tbody>
</table>

### 3 EXPERIMENTAL RESULT

The result of these long-term investigations indicates that the rate and magnitude of deflection for the composite beams under sustained load is affected by a change in moisture content. Most of the change in deflection occurs within period during which moisture content cycle takes place. A significant effect on deflection was observed in period during which the moisture content cycle took place. The data clearly shows steady increase in creep for both beams with time. The results of the mid-span deflection markedly increased during the first one year. A comprehensive plot of the test result showing the mid-span deflection, moisture content is shown in Figure 3.

### 4 CONCLUSIONS

This paper presents a long-term experimental investigation on timber composite beams. Even though definitive conclusions cannot be drawn yet, the cycling of the moisture seems to have induced a significant effect on the long-term deflection of the beams. And both the beams deflected more than two times of their instantaneous deflections. There are no provisions for creep factor of a composite LVL beams, however Euro code 5 recommends a creep factor of 2 for LVL under environmental conditions classified as service class 3[4].

### ACKNOWLEDGEMENT

The authors wish to acknowledge STIC (Structural Timber Innovation Company) for their financial support for this research.

### REFERENCES


