

# Long creep-recovery behavior of bamboo-based products

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**Introduction:** Research and development of engineered bamboo products is increasingly explored to design sustainable building materials for the built environment. While the use of bamboo is hampered by the lack of engineering data for creep and recovery properties. Two examples of engineered bamboo, **bamboo-laminated veneer lumber (BLVL)** and **glued-laminated bamboo (GLB)** were investigated, which structure and element shape were representative, has been gradually used in buildings and bridges in China.

**Materials:** Creep and recovery behavior of BLVL and GLB were studied under a four-point bending tests. The size of all the specimens was 500 mm × 20 mm × 20 mm. The span length was 360 mm and the load span length was 120 mm. Three different series of load levels were applied, which was 30, 50, and 70% of maximum load. Bending creep tests were carried out for 6 months (June–November) and then recovered for another 6 months(December–June).

**Results:** The relative creep was calculated ranging from 0.19 to 0.49 for BLVL, increased by 1.58 times when the stress level

increased from 30 to 70%. For the GLB products, the relative creep was ranged from 0.41 to 0.56, which increased by 0.36 times compared to the BLVL. It is seen that the increase rate for BLVL (1.58 times) was much higher than that of GLB (0.36 times).

After the load was removed, the instantaneous recovery ratios were decreased from 85.48 to 71.40% for BLVL while 95.77–54.36% for GLB. The results indicated that instantaneous reduced recovery ratio reduced as the stress level increased. The creep rate highly correlates to the applied stress. From our test data, the initial creep rate at stress level of 50% was two times (0.615/0.3) higher than that at a stress level of 30% for the BLVL samples, while 1.8 times (1.56/0.85) higher for the GLB samples

- Conclusion:**
1. The stress level was more sensitive on creep property for BLVL than GLB.
  2. The creep resistance of GLB was worse than that of BLVL from stress level of 30–50%.
  3. GLB has a better instantaneous recovery ability.

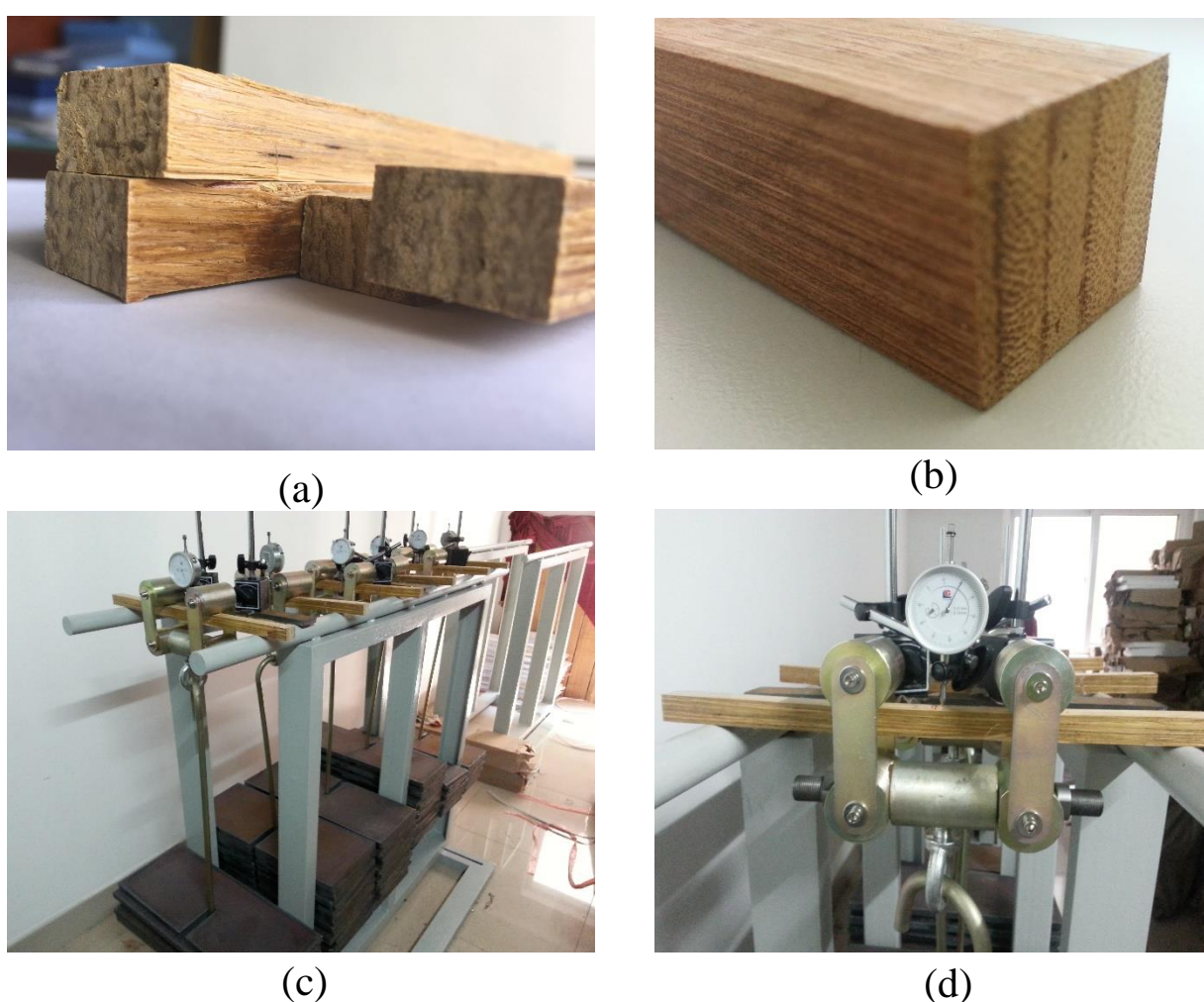


Fig.1 (a) BLVL (b) GLB (c)~(d) Creep test

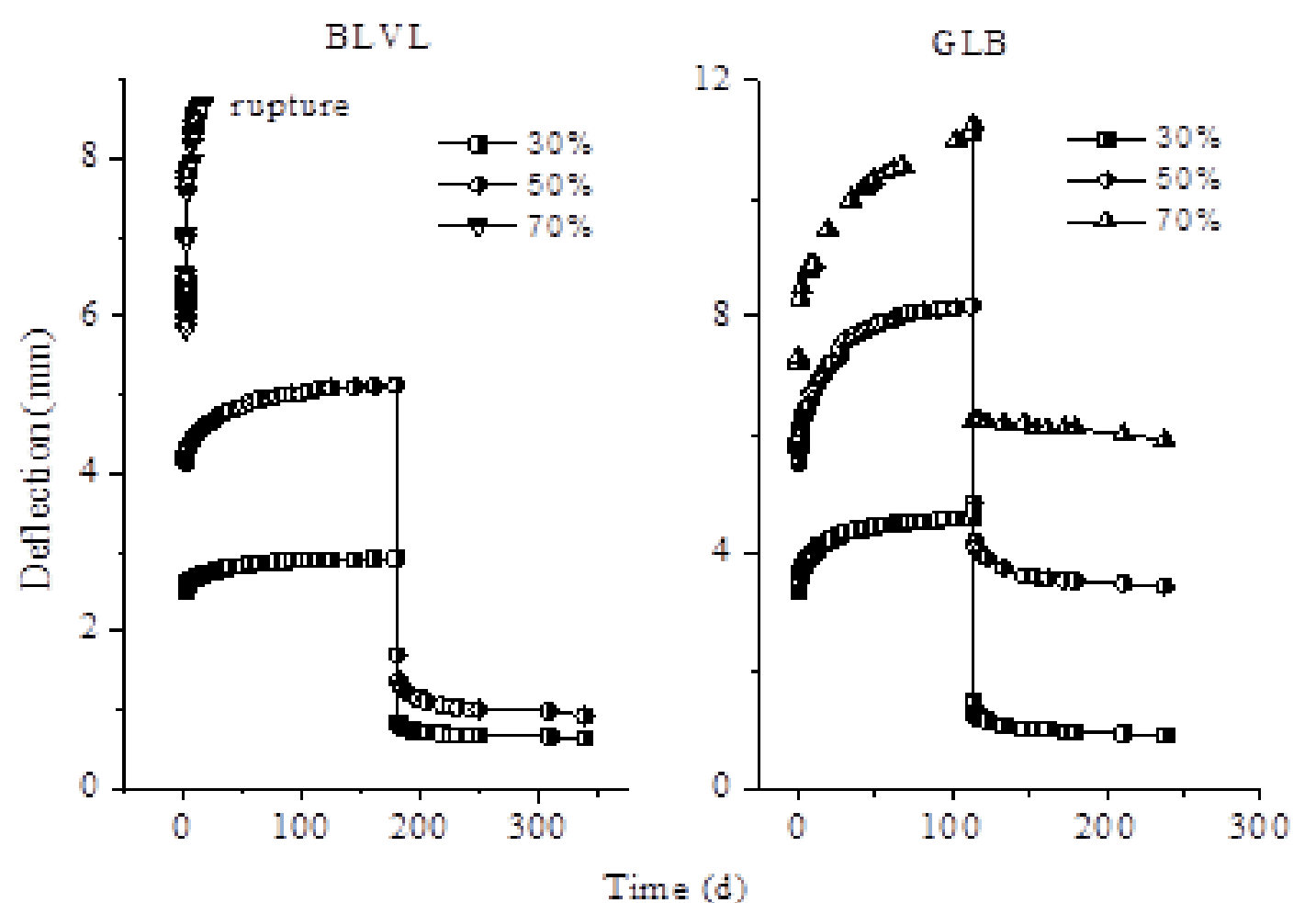


Fig.2 Creep-recovery curve of BLVL and GLB

Table 1 Mechanical properties of two panels

| Material type | Density (g/cm <sup>3</sup> ) | MOR (MPa) | S. D. (MPa) | MOE (GPa) | S. D. (GPa) | Maximum load (N) |
|---------------|------------------------------|-----------|-------------|-----------|-------------|------------------|
| BLVL          | 0.90                         | 193.65    | 8.8         | 24.14     | 1.25        | 4505.00          |
| GLB           | 0.75                         | 93.73     | 11.7        | 9.72      | 2.21        | 2022.00          |

Table 2 Creep-recovery parameters at different loading stresses

| Material | Stress | Creep               |                     |                | Recovery            |                     | Recovery Ratio (E <sub>r</sub> /E <sub>c</sub> ) | Residual Ratio (R <sub>d</sub> /T <sub>c</sub> ) |
|----------|--------|---------------------|---------------------|----------------|---------------------|---------------------|--|--|
|          |        | E <sub>c</sub> (mm) | T <sub>c</sub> (mm) | R <sub>c</sub> | E <sub>r</sub> (mm) | R <sub>d</sub> (mm) |  |  |
| BLVL     | 30%    | 2.48                | 2.95                | 0.19           | 2.12                | 0.61                | 85.48%   | 21.69%   |
|          | 50%    | 4.45                | 5.28                | 0.19           | 3.27                | 1.63                | 71.40%   | 30.87%   |
|          | 70%    | 5.84                | 8.69                | 0.49           | –                   | –                   | –  | –  |
| GLB      | 30%    | 3.31                | 4.66                | 0.41           | 3.17                | 0.89                | 95.77%   | 19.10%   |
|          | 50%    | 5.51                | 8.30                | 0.51           | 3.95                | 3.18                | 71.62%   | 38.31%   |
|          | 70%    | 7.23                | 11.26               | 0.56           | 3.93                | 6.90                | 54.36%   | 61.28%   |

Notes: E<sub>c</sub>: Elastic deformation; T<sub>c</sub>: Total creep; R<sub>c</sub>: Relative creep ((T<sub>c</sub>-E<sub>c</sub>)/E<sub>c</sub>); E<sub>r</sub>: Elastic recovery; R<sub>d</sub>: Residual deformation. Some of these parameters are shown in Fig. 6. BLVL: bamboo laminated veneer lumber; GLB: glued laminated bamboo.