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WOOD FRACTURE PATTERN DURING THE WATER DESORPTIO PROCESS

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ABSTRACT

Wood is a hygroscopic material and its mechanical properties change with moisture con below the fiber saturation point. Fracture characteristic is one of most important mechan properties of wood and often is taken as an important safety design factor for wood as an enginee structural material. The aim of this paper is to investigate the effect of moisture content chan on wood fracture properties, focusing on fracture behavior and patterns with different cr orientations of *Betula platyphylla Suk*. and *Pinus bungeana* in two different desorption proces These two desorption processes were, respectively, from fiber saturation point to an equilibr moisture content corresponding to 82.4%RH at 20ºC and from 82.4%RH to 35.2%RH at the sa temperature of 20ºC.

Keywords: water desorption, wood fracture

INTRODUCTION

Wood fracture performance is influenced by temperature and moisture content with moist content having significant impact. Smith and Chui (1994) sampled material in green condi from flat sawn boards from three premature red pines grown in New Brunswick, Canada. T concluded that reduction in moisture content at test from the fiber saturation point to 18% resu in an increase in mode I energy for complete separation of fracture surfaces and crack growt the longitudinal direction. However, below 18% MC, any reduction in MC at test led to a reduct in fracture energy. Kretschmann and Green (1996) studied effects of moisture content and spec gravity for clear southern pine and concluded that mode II stress intensity factor increases as decreases, reaching a maximum between 10 and 12% MC for all levels of density. They a found that mode I stress intensity factor increases as MC decreases, reaching a maximum betw 7 and 9% MC for all levels of density. In our previous paper (Wang et al. 2003), wood fract pattern was investigated under different relative humidity environment in moisture adsorp process. The objective of this work was to investigate the wood fracture behavior in mois desorption process on the effect of water transition on wood fracture properties, using a sim techniques as discussed in the previous paper (Wang et al. 2003).

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EXPERIMENT MATERIALS AND METHODS

Test specimen preparation

In the experiment, *Betula platyphylla* Suk. and *Pinus bungeana* were used and the sampling met followed the Chinese National Standard GB1927-91(1992):for tree sampling collection for phys and mechanical tests of wood. Specimens included four different orientations TL, TR, LR, LT pla Here, the first letter denotes direction normal to crack plane and the second one denotes directio crack. An edge crack was cut in the center of the specimen using a fine saw blade and the crack tip sharpened. The TL and LT specimen dimensions were 85 (length) x 15 (width) x 5 mm (thickne The corresponding dimensions for TR samples were 95 x 20 x 10 mm, and those for LT samples (*Pi bungeana*) were 120 x 20 x 10 mm.

Fracture testing

The strong and weak degree of stress field near the tip of crack is determined by stress inten factor K_I. Plane strain fracture toughness K_{IC} is the critical stress intensity factor when wood cr starts to propagate under static loading. Specimens were tested by universal mechanical testing mach at a rate of 0.5 mm/min and for each specimen, images were captured at various load levels u failure. The test method of fracture toughness followed the Chinese National Standard GB4161 (1985) for plane-strain fracture toughness of metallic materials. This method is not completely suita for an orthotropic material such as wood, but it is acceptable when the orthotropic main axis direc is superposed with the crack surface direction, as well as the crack propagation direction. Theref the above method is suitable for TL and TR specimens because of their crack propagation along wood initial crack. But for LR, LT specimens, as crack growth sloped from the initial crack direct the fracture toughness value measured can only be considered nominally for reference.

Water desorption experiment

In order to inspect wood fracture pattern under different relative humidity in desorption proc the samples were initially dried to the fibre saturation point and then exposed, respectively, to 82 RH and 35.2%RH at 20ºC. The relative humidity environment was created by the sulfuric acid wa solution and the temperature was controlled by a constant temperature box. During the desorp process, some specimens were taken out at different times to determine their moisture content fracture nature.

RESULT AND DISCUSSION

Wood fracture pattern in the first desorption step (82.4%RH)

Crack propagation path

In the desorption process, specimens' crack propagation path was the same as that in the mois absorption process (Wang *et al.,* 2003). Regardless of specimen types, all of their crack propaga occurred at the crack tips. The crack propagation direction of TL and TR specimens was consis with the original crack direction, and the fracture occurred as soon as their cracks were initia However, the crack of LT specimen started along initial crack direction, but, after very sh period of time, it changed the direction and propagated along the fiber direction. The cr propagation of LR specimen was complex, starting along initial crack direction in very sh period of time and then propagating in folding linear direction as shown in Figure 1.

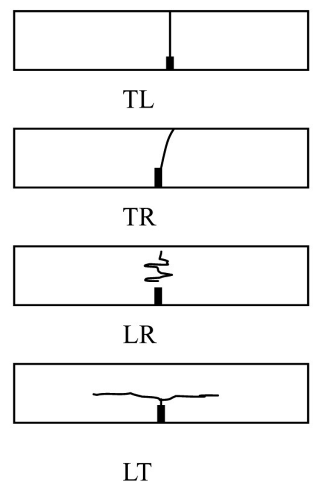

FIGURE 1. Crack propagation pattern in desorption process for the four types of specimens

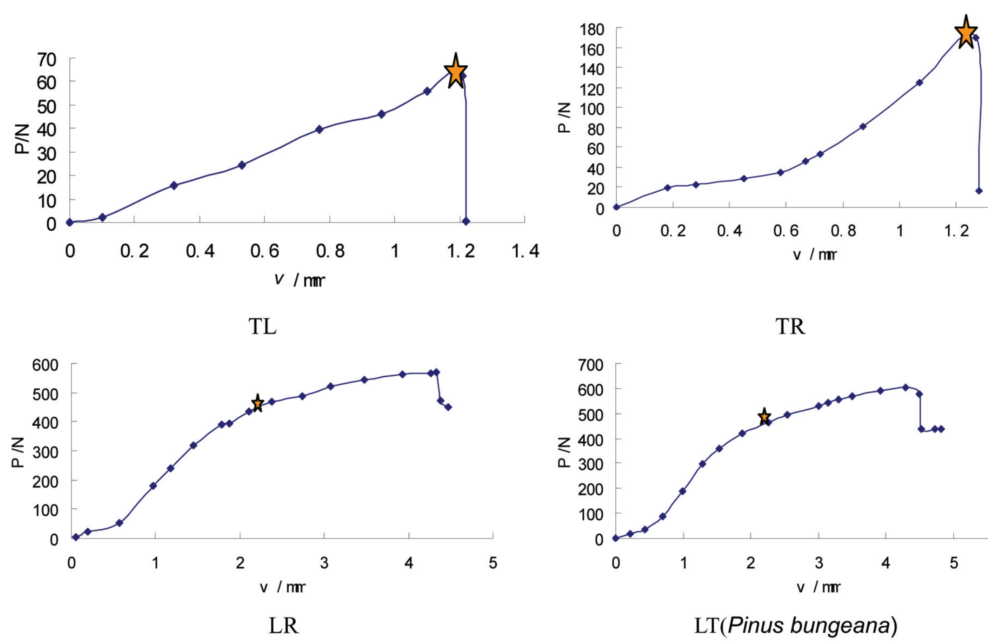

FIGURE 2. Load and displacement curve for specimens during the first step of desorption to 82,4% I

Critical load determination

From the experiments for TL and TR specimens, it was observed that the fracture occurred as s as the crack started to expand. Or in other words crack did not have obvious subcritical expansion these cases, the maximum load when the specimen ftacured is termed as the critical load, and the measu superposed the maximum load. Once crack started to grow, the load rapidly dropped and the test specim would fracture.

But for LT, LR specimens, crack would propagate slowly with different degrees and no obvi symptoms were observed when crack began to propagate before specimens fracture. From the point, maximum fracture load was no longer taken as the critical load. During specimen testing, «burst o sound was frequently heard clearly during rupture. Thus the 1st «burst out» load was taken as critical load P_Q as indicated by a start in Figure 2. Seen from figure 2, even if reaching the critical l P_Q, at which crack started to lose stability and propagate, the load continues to increase with cr growth. The specimen still has high load-bearing capacity after the 1st rupture. After reaching the larg load Pmax, the load dropped with crack growing and displacement increasing. By this point the specim had gradually lost its load-bearing capacity.

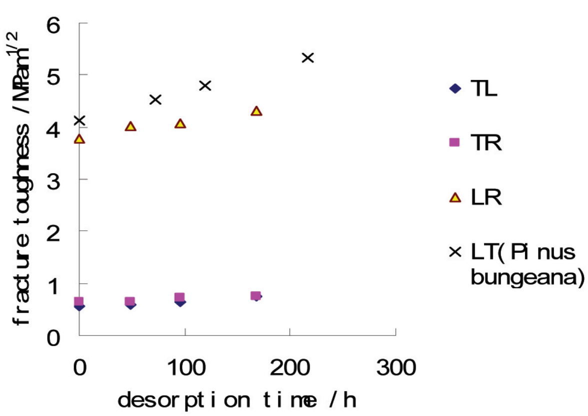

FIGURE 3 Fracture toughness of specimens during the first desorption stage at 20ºC (82.4%RH

Fracture toughness

Figure 3 shows the results of fracture toughness at different elapsed time during the first stag desorption (82.4%RH). Different specimen types had different fracture toughness values. But for ident specimen types under different time of equilibrium, their fracture toughness values were differe Specimen fracture toughness increased gradually with elapsed time during desorption, and the fract toughness of TL and TR specimens was quite close and its value was much lower than those of LR LT specimens.

Wood fracture pattern in the second moisture desorption stage (82.4% to 35.2%RH)

Crack propagation path

In the second desorption process, specimens' crack propagation path was basically the same as in the first desorption process. Thus the results in Figure 1 can represent those for specimens in second desorption process.

Critical load determination

The maximum load is higher in the second stage of desorption as the moisture content is lower can be seen from the experiment, the moisture desorption process would not strongly influence

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Regarding LT, LR specimens, critical load was still the load at some moment when the first clear
rupture» sound was heard.

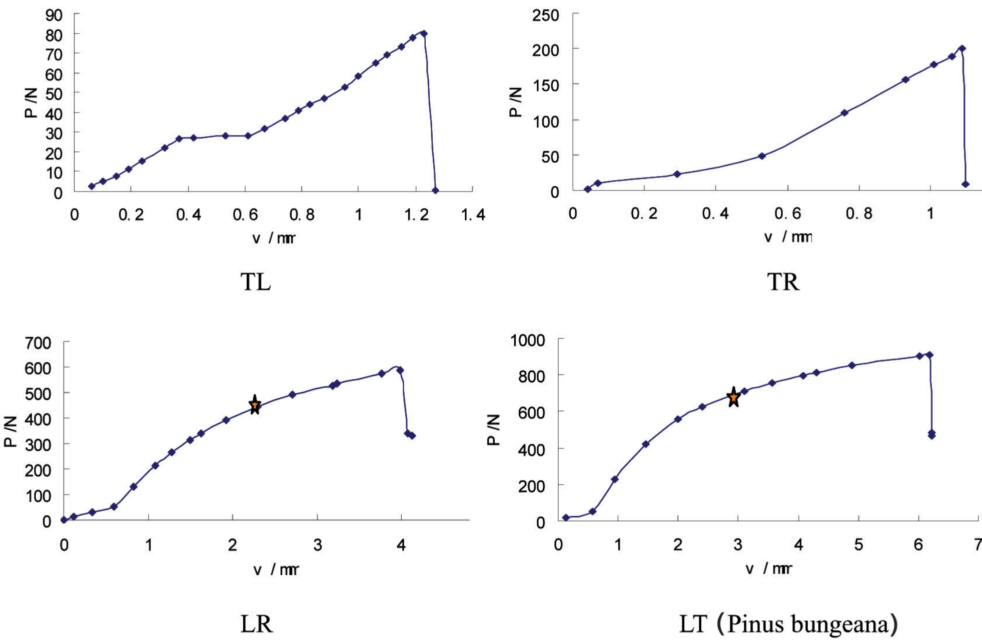
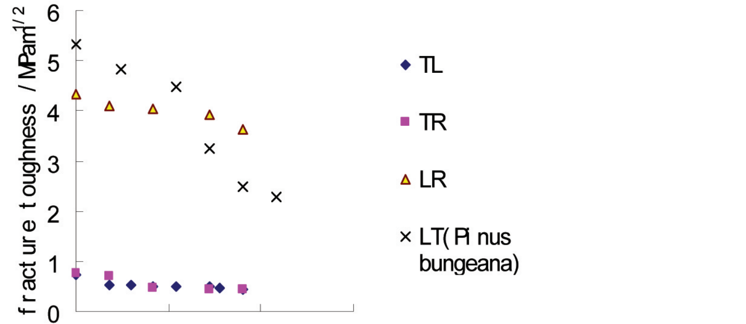


FIGURE 4. Load and displacement curve for specimens during the second desorption stage al 2
(82.4%RH⟶35.2%RH)

Fracture toughness

Seen from figure 5, in the second desorption process (82.4% to 35.2%RH), specimen frac toughness decreased with elapsed desorption time. This was opposite to that observed in the first st of desorption. Further examination for relationship between fracture toughness and moisture conte shown in Figure 6, below the fiber saturation point, for moisture content from 0 to 17%, wood frac toughness increased as MC increased, and reached the maximum value at the MC 17%. The frac toughness subsequently decreased with increasing of MC from 17% to 28%. Similar results have b found for fracture load for resistance to cleavage could reach the maximum value at the moisture con 18% (Mamada and Aoki 1992). Futher work is needed to understand the reasons for such behavio



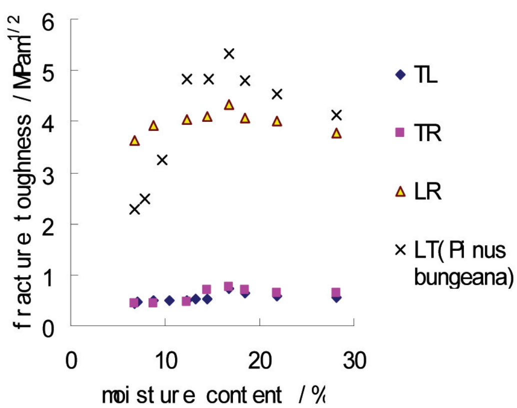


FIGURE 6 Relationship between moisture content and fracture toughness

CONCLUSION

In this work, it was found that for a given type of specimen, the crack propagation path in desorp follows a similar pattern to adsorption as observed in previous studies (Wang, *et al.*, 2003).

Specimen crack orientation was found to influence crack propagation path. The direction of cr propagation for TL and TR specimens was basically along the initial crack direction, namely TL specim propagate along the fiber direction, TR specimens along the radial direction or along wood ray direct

Moisture content in the wood influenced wood fracture toughness at a given temperature. For w moisture content change from fiber saturation point state to an equilibrium moisture content at 82% and 20ºC, fracture toughness for all of the specimens gradually increased with elapsed time. Howe with further desorption from 82%RH to 35%RH, wood fracture toughness decreased with time.

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