Application of Fracture Mechanics to Finger Joints

By

Lihong Shi

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Abstract

Application of linear Elastic Fracture mechanics to the finger joint was studied through three aspects: computational analysis, experiments and statistical methods. After the study these following conclusions were found:

1. There is an effect of material mechanical properties on the strength of a cracked body where material orthotropy exists. The degree of the effect depends on the loading configuration, crack(s) location and size and ratio(s) of material properties.
2. Collinear cracks across a slab can be simply treated as an edge cracked slab if the pitch of collinear cracks is three times of the length of a crack.
3. Strength of a finger jointed specimen is related to components material properties and finger profile.
4. A specimen made by high quality grade timber jointed to low grade timber usually has its strength is neither increased nor decreased, unless the outer finger root is located on the component made from high quality grade timber.
5. When a finger jointed specimen failed at the finger joint, the fracture mostly happened at the outer finger root, a small proportion had the fracture initiate from the first inner tooth root. Propagation of fracture either went straight up first or went straight inclined first. As long as the length of a shouldered specimen increases, the straight up fracture propagation, F11 failure mode, becomes more unlikely.
6. Linear fracture mechanics can be applied to a finger jointed specimen but the implementation would not be simple. The direct implementation of linear fracture mechanics to finger jointed problems may lead to the unsatisfaction results and not be useful for practice.
7. Applied statistics to the test results, and the characteristic strength of a finger jointed specimen was evaluated. The lower tolerance limits of modulus of rupture for different finger profile finger jointed specimens is greater than the lower tolerance limits of timber grade F5. Finger jointing applied to lower grade timber will not reduce its lower tolerance limit (L.T.L.) but increase it. Apparent fracture toughness then was calculated based on the characteristic strength, and it was related to the thickness of a finger or length of a shoulder.

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Glossary of Terms

C. D. F.:	cumulative distribution Function
C. F.:	cumulative frequency
D_{failed}:	material density of failed component of a tested specimen
$D_{survived}$:	material density of survived component of a tested specimen
$D_{survived}$ - D_{failed}:	difference of material density of survived and failed components in a tested specimen
$D_{specimen}$:	material density of a tested specimen
E:	modulus of elasticity
E_{failed}:	modulus of elasticity of failed component of a tested specimen
$E_{survived}$:	modulus of elasticity of survived component of a tested specimen
$E_{survived}$ - E_{failed}:	difference of moduli of elasticity of survived and failed components in a tested specimen
$E_{specimen}$:	modulus of elasticity of a tested specimen
F1:	specimen failure mode, brittle fracture starting from “the first finger root from bottom surface” or “shoulder”: with fracture plane initially vertical or then deviating across specimen at some angle (F11) (see figure 4.13), with the fracture plane at some angle to across section (F12) (see figure 4.14).
F2:	specimen failure mode, brittle fracture starting from “the second finger root from bottom surface”: with fracture plane initially vertical or then deviating a cross specimen at some angle (F21) (see figure 4.15), with fracture plane at some angle to across section (F22) (see figure 4.16).
F3:	specimen failure mode, brittle fracture starting from “non-finger” section
F4:	specimen failure mode, brittle fracture starting from “knot”
K_{Ic}:	opening mode critical stress intensity factor or fracture toughness
K_I:	opening mode stress intensity factor
K_{Io}:	open mode edge crack stress intensity factor subject to 3-point bending
$K_I/\sigma\sqrt{\pi c}$:	normalised stress intensity factor for centre crack or double edge cracks subject to uniform tension
K_I/ K_{Io}:	normalised stress intensity factor for edge crack subject to 3-point bending
K_{iso}:	stress intensity factor for isotropic material
K_{orth}:	stress intensity factor for orthotropic material
L:	distance of the centre of cross section of a component to the pith of timber

L_{failed}: distance of the centre of cross section of failed component to the pith of timber, measured by mm

$L_{survived}$: distance of the centre of cross section of survived component to the pith of timber, measured by mm

L. T. L.: lower tolerance limits

MOE: modulus of elasticity

MOR: modulus of rupture

SIF: stress intensity factor

S: annual rings spacing on the cross section of a component, measured by mm

S_{failed}: annual rings spacing on the cross section of a failed component, measured by mm