

## EFFECTS OF RATE OF LOADING AND MOISTURE ON DOWEL BEARING STRENGTH OF JACK PINE

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*The dowel bearing strength (embedding strength), along with the connection geometry is one of the main parameters used for calculation of the dowel-type connection resistance. This research was focused on the effects of three moisture contents and seven rates of loading on the embedding strength of jack pine (*Pinus banksiana*) wood. The loss of resistance with increasing time to failure was compared to empirical equations found from past research. Test results were correlated to the adjustment factors used in the Canadian (CSA O86) and European (EN 1995) timber design codes. The strength adjustments in the CSA O86 were found satisfactory whereas those in Eurocode 5 appeared non-conservative.*

***Duration of load, service conditions, embedding strength, strength adjustment, timber design code.***

### INTRODUCTION

Duration of load (DOL) effects on wood strength in bending, compression and torsion have been studied in the past under a constant load or step ramp loading, under controlled rate of deformation or controlled rate of loading. Wood (1951), Pearson (1972) and Gerhards (1977) established DOL empirical equations from bending and compression tests on small defect free specimens under various rates of loading. These equations define the loss of strength using the stress level (SL) and logarithm of time to rupture. The moisture content (MC) of wood varies with service conditions, which also affects its mechanical properties below the fibre saturation point. Rammer & Winistorfer (2001) studied the effect of MC on the dowel bearing strength and proposed a linear regression equation relating the two parameters. In the Canadian timber design code (CSA O86), factors KD and KSF are used to adjust the strength of fastenings for the DOL and service conditions, respectively. In Eurocode 5 (EN 1995), the adjustment factor  $k_{mod}$  is used to account for both effects simultaneously. The objective of this research was to study the influence of the rate of loading and MC on the dowel bearing strength (embedding strength) of wood, which is one of the main parameters used for calculation of the lateral resistance of dowel-type connections.

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## METHODOLOGY

Wood samples of 31 × 89 × 660 mm in size were cut from unseasoned jack pine (*Pinus banksiana*) lumber and graded to attribute an equal wood quality and density distribution to each test series consisting of six specimens. Then the wood samples were conditioned to achieve the following equilibrium MC levels: wet ( $\geq 24\%$  MC), dry (12% MC), and very dry (8% MC).

After the wood conditioning, test specimens were assembled with bolts of 12.5-mm in diameter and 6-mm thick steel side plates at each end (Figure 1) and tested until rupture using one of seven rates of loading, which varied between 115 kN / min and 0.1N / min, in each moisture condition. Tests that lasted longer than 10 min. were conducted in a chamber with controlled temperature and humidity conditions to maintain the target equilibrium MC. After the test, the actual MC and density of each embedment zone were determined and the following mechanical properties were calculated: elastic stiffness, proportional limit, yield point, and maximum resistance.

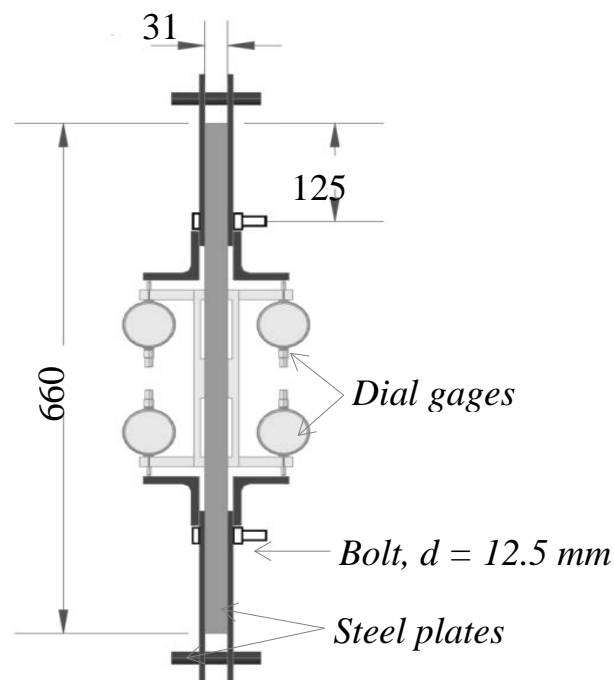


Fig. 1. Test specimen assembly.

## RESULTS

Test results confirmed that the elastic stiffness and the embedding strength of wood diminish with time under the load and in wet service conditions. It was also observed that the strength of wood in very dry condition (8% MC) reduced with time at a higher rate than in normal condition (12% MC). To compare the test results with the empirical

equations, the maximum resistance at 12% MC and one minute to rupture was adopted as a reference value. The average maximum resistance of each test series was then divided by the reference value to determine the loss of strength (stress level) for each rate of loading and moisture condition. The stress levels (SL) for each test series are plotted against the time to failure ( $t_f$ , min.) And are compared with the empirical equations in Figure 2. Test values at 12% MC appear to fit quite well the Pearson's (1972) equation:

$$SL = 100 - 6.4 \log_{10} t_f$$

The stress levels were also compared with the combined effect of the adjustment factors KD and KSF used in the Canadian design code (CSA O86) for different DOL and service conditions of fastenings, respectively. The KD appeared satisfactory if based on 10-min. load duration. The KSF appeared accurate for the resistance reduction between dry and wet conditions. Comparisons with Eurocode 5 (EN 1995) showed that  $k_{mod}$  significantly underestimates the reduction of the embedding strength in wet service conditions.

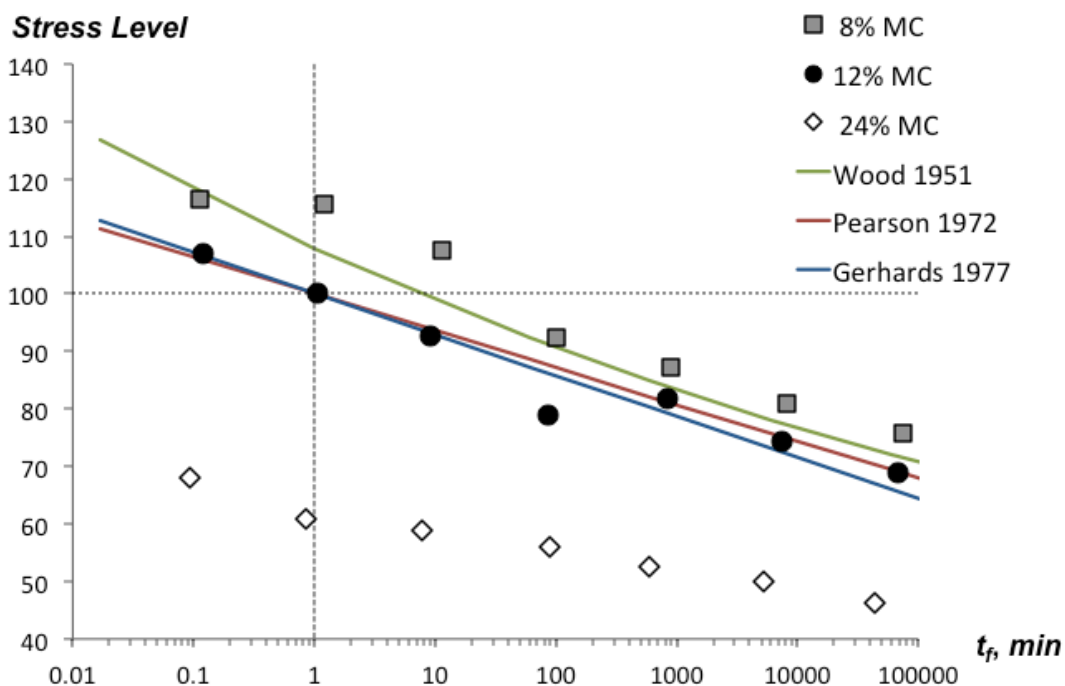


Fig. 2. Empirical equations and test results.

## CONCLUSIONS

Test results showed that the empirical equation by Pearson (1972) predicted the stress levels of the dowel bearing strength for the dry conditions in long term loading fairly well. The Canadian design code adjustments for wet service conditions of fastenings (KSF) and load duration (KD) may be considered satisfactory, whereas the Eurocode 5

adjustment factor ( $k_{mod}$ ) seems to underestimate the strength reduction in wet service conditions.

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*Nesuschaya prochnost pins (prochnost telescope), as well as Geometry compounds javljaetsja one IZ hlavných parameters USED for calculating Resistance Slot-type compounds. This is sosredotocheno That was the Study on effekte Trejo LEVEL LEVEL humidity and seven load forces on Attachment timber sosny Banks (Pinus banksiana). Resistance rubbed with techenyem of time to razrushenyya compared with empyrycheskymy equation byly vzyaty IZ proshlyh research. Results tests of byly sootneseny with popravochnymi koэфfytseyenamy USED in the Canada (CSA O86) and evropeyskym (EN 1995) Regulations design. Amendments prochnosty in CSA O86 byly pryznаны udovletvorytelнымy, togda How is something in Evrokod 5 okazalys without prochnosty stock.*

***Duration load, terms ekspluatatsyy, vlozhennaya prochnost, regulation forces Designing Regulation***

*The bearing strength of pins (embedded strength) and geometry connection is one of the main parameters used to calculate the resistance connections shponkovoho type. This study focused on the effect of three levels of humidity and seven levels of stress on the attachment strength of wood Jack pine (Pinus banksiana). Loss of resistance over time to fracture compared with empirical equations were taken from previous studies. The test results were correlated with the correction factor used in the Canadian (CSA O86) and European (EN 1995) design regulations. Amendments strength CSA O86 were found satisfactory, while those in Eurocode 5 were no safety margin.*

***Duration load, Operating conditions, embedded strength regulation forces design rules***