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Technical Note 1

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FACTORS AFFECTING DISTRIBUTION OF BORATE TO PROTECT BUILDING ENVELOPE COMPONENTS FROM BIODEGRADATION

KEYWORDS: Borate; Pretreatment; Cross laminated timber

OVERVIEW OF PROJECT

Timber components in the building envelope become subject to decay and mould growth if there is presence of water for a prolonged time and exclusion of water is not ensured by the building design or construction practices. When the wood components are designated for vulnerable areas such as window frames or structural components not properly protected from exposure, use of a preservative can increase the lifespan of the building components significantly. However, not all available preservatives are suitable for residential use due to labeling restrictions and technically, because they cannot be applied without pressure treatment. In this regard, borate can be a potential candidate as it is free of all these drawbacks and can be used effectively as pre-treatment or 'in-situ' treatment to protect building envelope components from biodegradation. The following challenges or research gaps were identified where further investigation was necessary.

1) There is limited specific information on lower moisture content limits, borate distribution rate and extent and how these interact with formulation type and wood species.
2) Inadequate quantitative information is available about the factors affecting distribution of borate in wood. So it is necessary to examine refractory wood species for the same purpose.
3) There is a lack of information on the relationship between amount of chemical applied in different ways and the volume of wood effectively protected. This information is important to know in order to improve the efficacy as well as the cost-effectiveness of the preservative.

The following are the main objectives for this research:

1) To investigate variables affecting borate movement
2) To evaluate and develop suitable borate treatment procedures for timber components, joints and other vulnerable areas
3) To investigate the suitability of borate preservatives for cross-laminated timber (CLT)

Test specimens were impregnated with water to a prescribed moisture content, treated with formulations prepared in the lab and kept for certain periods to permit borate diffusion inside the samples. Two highly concentrated formulations were applied and a novel approach (borate bandage) was used to keep the preservative on the surface and enhance the diffusion by reducing surface drying. Samples were extracted with hot water and borate concentrations at different distances along the diffusion path were measured by ICP analysis. Statistical significance of the factors affecting borate diffusion was evaluated for different depths acquired and diffusion periods. Effects of moisture content, grain direction, species and formulations were evaluated by ANOVA and post-hoc (Tukey HSD and Scheffe) analysis. Diffusion coefficients for different borate formulations at different moisture content and grain directions were calculated to evaluate comparison and provide a quantitative measurement to understand the diffusion of borate in refractory species. A mould test was also performed to determine the efficacy of the formulations and necessity of co-biocides.

KEY RESULTS

- Grain direction and moisture content affect boron distribution more significantly than species and formulation. Longitudinal diffusion is much higher than radial and tangential diffusion and diffusion in the

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radial direction is higher than in the tangential direction. This is more obvious at higher moisture content (>30%). An effective level of protection (more than 0.2% BAE) can be achieved at maximum distance (ca. 4 cm) in the longitudinal direction with both formulations at 70% moisture content (in 21 days). After this time there was still a high concentration of borate present near the surface and over a longer test period, borate should diffuse much further at levels high enough to stop or prevent decay.

 Boron diffusion extent was always higher with higher wood moisture content. However, this was more obvious in the longitudinal direction and least obvious in the tangential direction.

 Spruce samples showed slightly better diffusion results than Douglas-fir samples.

 A copper borate formulation had better diffusion extent than a glycerol borate formulation, especially in the longitudinal direction and at higher moisture content.

 Average longitudinal diffusion coefficients were about 7 times higher than tangential diffusion coefficients and about 3 times higher than radial diffusion coefficients. Average diffusion coefficients at 70% moisture content and 50% moisture content respectively were around 8 times and 3 times higher than at 30% moisture content. Copper borate had higher diffusion coefficients than glycerol borate, but no significant species differences were seen.

 Under high humidity (95% R.H.) exposure situations, the formulations show some resistance to mould growth and copper borate showed better results than glycerol borate.

 The fire retardant property of borate was observed in a preliminary test (ASTM D3806 2-foot tunnel) in which glycerol borate performing better than copper borate treatment.

 From the average results in the standard mould test, use of copper borate formulation shows marginal potential to prevent mould growth compared to untreated samples and addition of DDAC with the formulation may give better protection whereas spruce itself has some mould resistance as it is hard to get wet.

Recommendations:

 Pretreatment can be applied to lumber to protect building envelope components from bio-degradation, because if there is water accumulation inside the structure, borate can easily diffuse into the vulnerable area due to concentration differences. This is also true for engineered wood products with solid lumber such as cross laminated timber (CLT).

 To protect from mould, addition of a co-biocide such as DDAC appears to be effective.

 Topical application of fixed amounts of borates indicated that copper borate treated spruce samples showed better protection than glycerol borate in most cases. It is also noteworthy that high concentrations of borate were still present near the treated surfaces of the samples after 21 days of diffusion which could possibly diffuse deeper if the samples were kept in the same moisture content condition for a longer period of time.

 'In situ' treatment can be a good method with borate formulations, but the high concentration should be kept on the surface by bandage or the component should be wet enough to start boron diffusion. Application of an impervious bandage to the surface-applied treatment facilitates treatment by preventing loss of the borate from the surface and preventing surface drying.

THESIS

Md Saadat, N. 2012 Factors affecting distribution of borate to protect building envelope components from biodegradation. MScF thesis. University of Toronto, Toronto, ON.