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IMPROVEMENTS TO HIGHWAY GUARDRAIL ASSEMBLIES

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ABSTRACT: Highway guardrail assemblies play an important role in enhancing the safety of motorists. It is essential that the blockouts are durable so that the guardrail assembly can function properly. The goal of this study was to explore the feasibility of using recycled CCA-treated wood to produce a composite blockout. Decommissioned blocks were chemically analysed and found to contain residual CCA that is consistent with over ten years of service. The used bocks were ground to particles, combined with polypropylene (plastic) and made into groups of composite blockouts with varying amounts of wood, plastic, block density, and resin. One yielded superior results: internal bond strength (744.66 KPa), modulus of rupture (17.49 MPa), modulus of elasticity (3.04GPa), linear expansion (1.605 cm.), and thickness swelling (12.6%). The finite element analysis revealed that a guardrail assembly comprised with wood/plastic blockouts should perform similar to one with solid wood blockouts.

KEYWORDS: Highway guardrail assemblies, Blockout, CCA-treated wood, Composite blocks

1 INTRODUCTION

Guardrail assemblies are an important means to increase the safety of highway travel. A typical installation includes a series of metal guardrail attached to wooden posts that are driven into the ground. The blockouts connect the wooden posts to the metal guardrail. Blockouts help absorb kinetic energy during a vehicular crash. Since steel blocks were proven ineffective based on NCHRP 350 [1], the primary material for new blockouts is wood, which is frequently preservative treated with chromated copper arsenate (CCA). Non-wood blockouts have gained market share in recent years. However, a recent study found that CCA treated wood guardrail posts offer notably lower environmental impacts for fossil fuel use (almost half), net greenhouse gas emissions (one-sixth), acidification (approximately half), and ecotoxicity (approximately half) relative to galvanized steel posts[2].

Eventually, the posts and blockouts are decommissioned and disposed as wastes. However, disposal of spent preservative-treated wood has increasingly become a major concern because of its residual preservative content. Popular waste disposal options for spent preserved wood, such as incineration and landfilling, are becoming expensive or even impractical because of increasingly strict regulatory requirements. Average landfill tipping fees in the United States increased from $8.20 per ton in 1985 to $32.20 per ton by 1995, according to surveys conducted by the National Solid Waste Management Association In 2013 the US average tipping fee was $49 per ton with a maximum of $91 per ton in Maine [3].

One of the direct recycling options for preserved wood is for composite manufacturing. Research results of Munson and Kamdem showed that particleboard made from 50% of furnish made from CCA-treated utility poles and 50% untreated wood displayed comparable durability properties with those made from entirely from untreated wood [4]. A preliminary study on composite guardrail blockouts was conducted in our previsous research. The materials used to fabricate blockouts were fresh untreated wood particles and urea-formaldehyde and isocyanate adhesives. The composite blockouts were molded in a steel mold at 175°C for 60 min. The durability and strength test results showed that molded composite guardrail blockouts had the potential to be an alternative to solid wood blockouts. This study was a key advancement in the development of this product because traditional hot pressing techniques cannot be used to produce such a thick product. Additional research is necessary to use decommissioned CCA-treated wood, which is more difficult to bond that untreated wood, and to refine the process variables.

Utilization of treated wood to make guardrail blockouts converts the decommissioned treated wood to new composite treated wood products and extends the service life of the wood. It is expected that this technique would be welcomed by the guardrail post and blockout manufacturers and purchasers because it will reduce production costs in terms of wood material and lessen disposal costs.

2 RESULTS AND DISCUSSION

Twenty decommissioned CCA-treated highway posts were recovered from two sites in Louisiana: (1) DeSoto Parish and (2) Ascension Parish. Determination of the

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properties of the raw materials, production and testing of molded guardrail blockouts, and finite element analyses and optimization design were conducted in this research.

2.1 PROPERTIES OF DECOMMISSED POSTS

Increment cores were taken from each sample and the data obtained are reported in Tables 1. The data indicates that the posts were properly treated in accordance with AWPA standards [5] and were likely in service for over 10 years. The samples from Ascension Parish showed a mean penetration of 6.93 cm. and 98% of the sapwood was penetrated by the preservative. The chemical analysis showed the retention of CrO_3, CuO, and As_2O_5 to be 0.300, 0.113 and 0.195 pcf, respectively (Table 2). The samples from DeSoto Parish showed a mean penetration of 4.9cm and 82% of the sapwood was penetrated by the preservative. The chemical analysis showed the retention of CrO_3, CuO, and As_2O_5 to be 0.301, 0.109 and 0.192 pcf, respectively (Table 2). All posts were considered to be typical and representative of posts and blockouts that are decommissioned for infrastructure improvements.

2.2 PRODUCTION AND TESTING OF MOLDED GUARDRAIL BLOCKOUTS

Three groups of composite blocks were produced: (1) wood 75%, polypropylene (PP) 25%, urea formaldehyde (UF) 8%, isocynate (ISO) 1%, 53 pcf, (2) wood 75%, plastic 25%, UF 8%, ISO 1%, 43 PCF, and (3) wood 87.5, plastic 12.5%, UF 8%, ISO 1%, 43 PCF. Blocks were pressed at 204ºC and 15 min press time. Six replications were made of each group. Samples were cut and tested in accordance with ASTM standards for IB, bending MOR, bending MOE, LE, and TS. Figure 1 illustrates some examples of the compression molded blocks that were fabricated.

Figure 1: *Guardrail block (Side view)*

Table 3 shows the MOR, MOE, and IB, respectively, of the test groups. Group 1 provided the highest values for all three mechanical properties. However, this finding is likely due to the higher density of Group 1. It is well established that most mechanical properties are well correlated with wood density. Therefore, from a logistics perspective Groups 2 and 3 merit consideration. These groups will be easier to handle and cheaper to transport in bulk. It is noted that AASHTO has no mechanical requirements for highway blockouts [6]. The blockout serves as an integral part of a guardrail assembly by securing the guardrail to the post. It is essential that the post yield the soil in the event of a vehicular accident.

Table 3: *Mechanical properties of composite blocks*

Sample	MOR (MPa)	MOE (GPa)	Internal bond (KPa)
Top	17.49	3.04	744.66
Bottom	1.04	1.87	613.655
Left	9.74	2.03	475.755

2.3 FINITE ELEMENT ANALYSES

A finite element model of the deformation and energy conversion was established. During the simulation, the rigid ball bounced back with a lower speed after collision into the guardrail. In the collision process, the deformation energy was less than the initial kinetic energy, while the final deformation energy and the final kinetic energy were equal to the initial kinetic energy.
In this analysis, the performance of a guardrail assembly featuring wood composite blockouts was no different than previous analyses by others of traditional assemblies with solid wood blockouts [7].

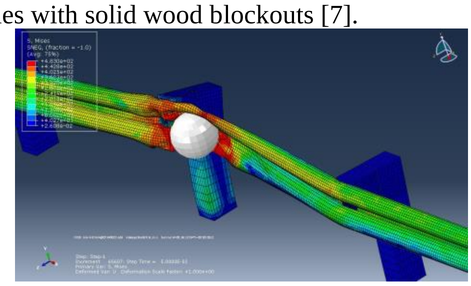

Figure 2: *Simulation of impact stress*

3 CONCLUSIONS

This study has shown that highway guardrail blockouts can successfully be produced from recycled CCA-treated wood. The material used to produce the blockouts was well treated and can be considered typical of the available resource. Three unique groups of composite blockouts were manufactured. Group 1 provided the highest values for all three mechanical properties. However, this finding is likely due to the higher density of Group 1. The findings of a simple finite element analysis of a guardrail assembly featuring wood composite blockouts was no different than previous analyses conducted by others of traditional assemblies with solid wood blockouts.

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