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Decay Efficacies of Plywoods Manufactured by ACQ-treated Veneers of Domestic Softwood and Hardwood Species

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Abstract: The eco-friendly preservatives such as ACQ or CUAZ have been used in landscape architectural facilities these days. In this study, the decay efficacies of ACQ treatments were evaluated according to domestic veneer species, concentration of ACQ, weathering test, adhesive type, and fungus type. In case of veneer species, hinoki cypress and yellow poplar showed the highest and lowest decay resistance, respectively. And the decay resistance appeared to be greater in plywoods bonded by resorcinol resin-bonded plywood and non-weathering treated plywood than polyurethane resin-bonded plywood and weathering treated plywood.

Keywords: *ACQ, decay efficacies, veneer species, concentration of ACQ, weathering test, adhesive type, fungus type*

1. INTRODUCTION

At present, plywood treated with a fire-retardant or a preservative is available in the market. In this relation, chemical retention and preservation effect must be enhanced. The higher decay resistance is inevitably required in the wood construction, especially earth-contacting members like sill plate. In these parts, the preservative-treated wood-based materials of plywood and LVL, etc. could be utilized.

On the other hand, new regulatory systems for biocides, including wood preservatives, have recently been introduced or will be soon introduced in many OECD countries. These new regulations require a comprehensive environmental risk assessment to take place for authorization decision-making purpose (OECD 2001a).

Since copper is the most widely used biocide for wood preservation, a major requirement of any formulation of copper-based wood preservative is efficacy against copper-tolerant fungi (Nicholas and Schultz 1997). Copper is the primary biocide in many wood preservative formulations used in ground contact because of its excellent fungicidal properties in fungi and low mammalian toxicity (Lebow 2010).

When considering eco-friendly uses of landscape architectural facilities, low toxicity-preservatives of ACQ (alkaline copper quaternary) or CUAZ (copper azole) must be preferred. ACQ has an active composition of 67% copper oxide and 33% quaternary ammonium compound, which consists of copper-soluted amin chemicals, and are treated into wood by pressure-impregnated method. After prohibition of chromated copper arsenate, copper-based water soluble preserva-

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tives such as ACQ and CUAZ have commonly begun to be used (Kim, 2013). ACQ treated wood, which is second generation of preservative-treated wood, reveals superior performance to decay of wood and attack of termite. Particularly, wood members have to be protected from decay fungi or harmful insects for outdoor use. In case of veneer laminated products, excellent bond performance should be recommended as well. When a phenol-resorcinol-formaldehyde adhesive was formulated for bonding treated wood, the resistance against delamination was in the order of CCA, CuAz, and ACQ (Frihart, 2003). In a report on the effects of preservative type and natural weathering on preservative component distribution, the average amounts of leaching was known to be 2.9% for ACQ-Cu in southern pine lumber (Copper and Ung, 2009).

The phenol-formaldehyde resin was known to be good for developing bond strength of pine-wood treated with CB-HDO or CY (copper azole). Resorcinolformaldehyde resin gave the best result when CB-HDO was used for the treatment of Korean pine (*Pinus koraiensis*) and Japanese larch (*Larix leptolepis*)(Lee *et al*, 2006).

In this study, decay efficacy of plywoods made of ACQ-treated domestic softwood and hardwood veneers were discussed based on adhesives, weathering treatment, and fungus types.

2. MATERIARS AND METHODS

2.1. Manufacture of preservative-treated plywood

ACQ (Alkaline copper quaternary) at the concentration of 0.05%, 0.3% and 0.6% were pressure-impregnated into 2.6 mm thick veneers of Korean pine (*Pinus koraiensis*), radiata pine (*Pinus radiata*), hinoki cypress (*Chamaecyparis obtusa*) and yellow poplar (*Liriodendron tulipifera*). The pressure-impregnation procedure was composed of a pre-evacuation in 650 mmHg for 15 min, a pressure-impregnation in 15 kgf/cm^2 for 30 min. and a post-evacuation for 5 min. Then, these 2.6 mm thick veneers were air-dried, and 5-ply plywoods were pressed and hardened at room temperature with resorcinol resin and polyurethane resin.

2.2. Weathering test

The plywoods manufactured by impregnation into veneers with ACQ at concentrations of 0%, 0.05%, 0.3%, and 0.6% were cut into specimens of 13 mm × 2 cm × 2 cm for decay efficacy test. Weathering treatment was carried out before decay efficacy test. For this procedure, plywood specimens were remained indoors for three weeks and then weathered. This weathering procedure was followed by leaching in the stirred water at 25℃ for 8 hours and drying in 60℃ for 16 hours after this leaching. This leaching and drying procedure were repeated 10 times, that is totally 10 days.

2.3. Decay efficacy test

The test was carried out in the plywood specimens with and without weathering treatment in conformance to KS M 1701, annex 2 of decay efficacy method of wood preservatives. For this test, 2 types of fungi of *Fomitopsis palustris* (FOP) and *Trametes versicolor* (TRV) were cultivated and infected on the specimens respectively. After 120-day exposure to fungi, the fungi-infected specimen were brushed with water and oven-dried at 60℃ for 3 days. Then, the decay efficacy was evaluated by the measurement of weight loss.

3. RESULTS AND DISCUSSION

As shown in Fig. 1, the retention amount increased with the increase of ACQ concentration, and retention was higher in the order of radiata

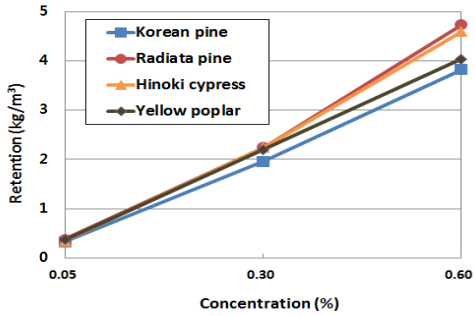

Fig. 1. Retention amount according to concentration of ACQ and veneer species.

pine, hinoki cypress, yellow poplar, and Korean pine at 0.6% concentration.

In Fig. 2, weight loss by FOP infection was remarkable in case of bonding with polyurethane resin. At 0.05% concentration, there was slight weight loss of resorcinol resin-bonded specimen by FOP infection, and there was also slightly weight loss of polyurethane adhesive-bonded specimen by FOP and TRV infection. However, there was little loss in both fungi-infected specimen at 0.3% and 0.6% concentrations regardless of weathering treatment.

Weight loss of control (ACQ non-treated) was relatively less in the radiata pine plywoods bonded with resorcinol resin than in those bonded with polyurethane resin, and the higher weight losses by weathering treatment occurred in both resorcinol and polyurethane resin bonded plywoods (Fig. 3). As a result, at concentration of 0.05% to 0.6%, polyurethane resin-bonded specimen generally resulted in lower resistance against infected fungi than resorcinol resin-bonded specimen. In case of plywood bonded by resorcinol resin, however, an exceptionally great degree of decay by FOP was observed in the weathered plywood at 0.05 and 0.3% ACQ concentration. This was thought that ACQ concentration less than 0.3% was susceptible to FOP due to leaching of preservative

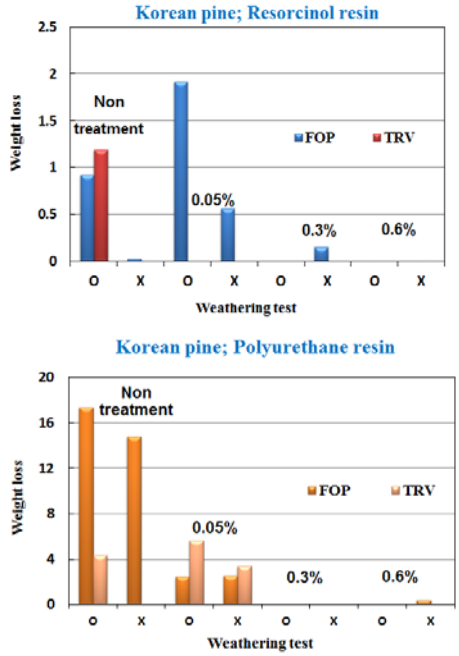

Fig. 2. Weight loss of ACQ-treated Korean pine plywood by decay efficacy test.

component during weathering treatment.

From Fig. 4, it was evident hinoki cypress to be resistant against fungi. Especially, ACQ-treated plywood showed higher decay resistance regardless of ACQ concentration, weathering treatment, and adhesive type.

As shown in Fig. 5, there were no decay efficacies by ACQ treated plywoods differently from control(ACQ non-treated) plywoods in case of resorcinol resin. At ACQ concentrations of 0.05%, 0.3%, and 0.6%, however, decay efficacies of plywoods without weathering treatment were much higher than those with weathering treatment in case of polyurethane resin. From this result, it was thought that ACQ chemical leached during weathering operation seemed to be the cause of weak resistance against fungal attack. Therefore, fungal attack appeared to be rather easily caused by unstable fixing despite of higher ACQ concentration in

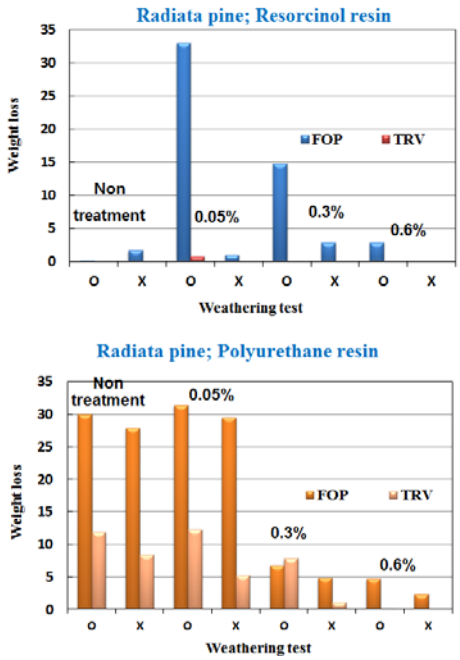

Fig. 3. Weight loss of ACQ-treated radiata pine plywood by decay efficacy test.

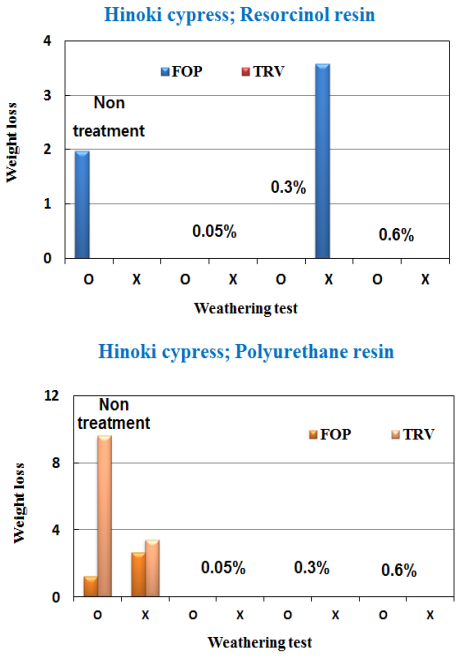

Fig. 4. Weight loss of ACQ-treated hinoki cypress plywood by decay efficacy test.

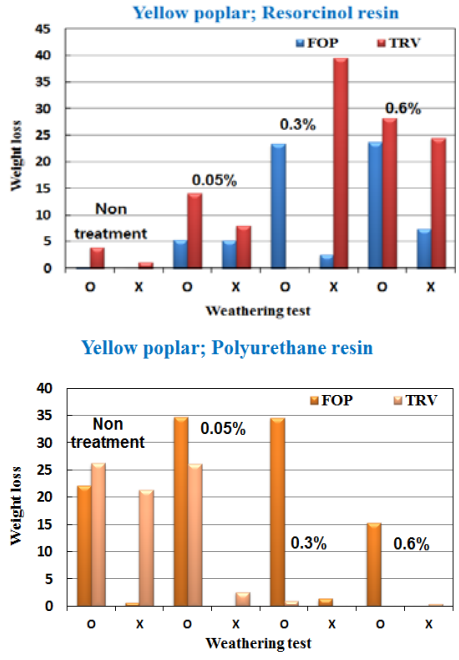

Fig. 5. Weight loss of ACQ-treated yellow poplar plywood by decay efficacy test.

resorcinol resin-bonded plywood.

In conclusion, there was difference in preservative-treatment effect and decay efficacy between species, and resorcinol resin-bonded plywood generally revealed high resistance against fungal attack irrespective of weathering treatment.

4. CONCLUSIONS

As a substitute for the CCA, eco-friendly preservatives such as ACQ or CUAZ have recently begun to be introduced. In this study, an evaluation of decay efficacies by ACQ treatments were conducted by domestic softwood and hardwood veneer species, concentration of ACQ, weathering treatment, adhesive type, and fungus type.

Except for yellow poplar, 3 veneer species of Korean pine, radiata pine, and hinoki cypress showed higher decay resistance at ACQ concen-

tration of 0.3% or more. In particular, hinoki cypress showed no weight loss to fungal attack even in low ACQ concentration regardless of adhesive type. In case of yellow poplar, however, there was no resistance against fungi even at the higher of concentration of 0.3% or more in plywood bonded by fungi-resistible resorcinol resin.

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AUS: 90-100 CCA; 8-10 Copper based alternative waterbornes; 11 Light organic solvent preservative (LOSP); 4 Creosote/Heavy Oil (reference OECD 2001a).

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