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ORGANISMS CAUSING DETERIORATION IN STRUCTURES

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Abstract

The abstract under this title in the first proceedings of the CWPA, authored by G. Rambo of the US National Pest Control association, focussed on the activities of the pest control industry. In the absence of a speaker from that industry I had planned to update my 2001 CWPA paper on biodeterioration, but there was not much new to talk about. I therefore decided to focus on people as the primary cause of conditions conducive to biodeterioration of wood in structures, and provide examples of the mistakes people make. These include underestimating the deterioration hazard, using designs that promote biodeterioration, using poor construction methods, using the wrong wood species, using untreated wood where treated wood should be used, using the wrong treatment, poor treatment processing, failing to use treated wood properly, and failing to do adequate maintenance.

1. Introduction

A presentation under this title was scheduled at the original CWPA annual meeting but unfortunately the presenter was unable to deliver the talk. There was no paper in the proceedings but the abstract authored by G. Rambo of the US National Pest Control association focussed on the activities of the pest control industry. The abstract mentioned termites, beetles, carpenter ants and wood destroying fungi. The pest control associations were approached to give a reprise of this paper at the 30^{th} annual meeting but they declined, so I was forced to step in. I gave a general presentation on biodeterioration as part of the back-to-basics theme at the 2001 meeting. A written paper is available in the proceedings or in the compendium. Not a huge amount has changed in terms of our knowledge of biodeterioration since 2001 and those who have been attending CWPA meetings will be well aware of any new knowledge. I therefore decided to take a different tack.

In 2001 I used one slide to illustrate the relative economic importance of various types of organisms causing deterioration in structures. I used a very small font for bacteria because only under very wet conditions over long periods of time can they cause serious damage. I used a slightly larger font for marine borers because, although they are ubiquitous and aggressive in Canadian waters, not much wood is used in the marine environment. I used a moderate sized font for insects, mainly to cover the termite damage in Southern Ontario and parts of BC, plus carpenter ants. Beetles have been a relatively minor problem for wood in structures in Canada. I reserved the largest font for fungi because they are generally considered to be the most economically important group of organisms causing biodeterioration of wood in Canada. Looking at that slide as I contemplated whether or not to update the 2001 presentation for the

30th annual meeting, I realized that there was another type of organism that was truly responsible for the overwhelming majority of wood deterioration. *Homo sapiens*. Us. I therefore set about to provide some examples of the ways in which people create the conditions for wood destroying organisms to thrive.

2. Observations

2.1 Underestimating the Hazard

People constantly underestimate the potential for moisture problems in buildings. This is because architects focus more on the look and function of a building than they do on its durability. The use of California style architecture in Vancouver's rainforest climate was a contributory cause of the $1 billion leaky condominium problem (Morris 2006). Bill Dost, formerly with the University of California in Berkeley said to me, "Stop blaming us. Those designs don't even work here".

Vancouver gets a lot of rain, over 1.0m per year, but it was not the volume that had been underestimated but its particular characteristics. Rather than being spread throughout the year, Vancouver's rain is concentrated between November and April. Rather than coming in heavy rainstorms where a lot of water simply runs off, Vancouver's precipitation comes as steady supply of light rain or drizzle that can be gradually absorbed. Periods of dry weather are short and infrequent during the winter. Rather than being evenly distributed around the compass, Vancouver's wind-driven rain is highly directional. Very early on in the saga of repairs to leaky buildings I noticed the blue tarps were more on the East side of the building than any other face. Looking closely at buildings not under repair, I noticed moisture staining on the East but not on the West facades. Checking out the Weather Channel, I found that just about every time it was raining, the wind was Easterly. A search in the literature confirmed my observations. While Vancouver's weather comes from the west, the wind direction during rain events is overwhelmingly from the East, North East and South East (Zhu et al 1995). This came as a complete surprise to the local construction industry. Buildings with inadequate overhangs had a massive rain load deposited on their East walls so any defects in design or construction were going to let in a lot of water. Once we began to understand the hazard and the effects of design and construction in causing moisture problems, it was possible to develop solutions that could restore the credibility of the wood frame construction industry in BC (Ricketts 1997, Morris 2006). Rainscreen construction and wide overhangs on East facing walls can minimize this problem.

That was simply failure to understand the existing moisture hazard. But what happens when the moisture hazards change without anybody noticing? The answer is that an entire industry segment can self destruct. In the late 1970s and early 1980s a new industry developed in Alberta producing untreated pine shakes for the rapidly expanding new subdivisions. Based on anecdotal evidence of good performance on farm buildings in the arid prairies, the use of untreated pine shakes as a substitute for western red cedar gained building code acceptance for use in low rainfall areas. One manufacturer used a map of the Scheffer index (Setliff 1986, Scheffer 1971) to delineate areas with moderate or high decay hazard where these shakes should be pressure treated. After only four years in service in Edmonton, a supposedly low hazard area, many of these pine shake roofs were showing signs of decay. There were a host of contributory factors but one of them turned out to be climate change. A recent revision of the Scheffer index based on the latest climate data showed that the moderate decay hazard zone has expanded to encompass Edmonton (Wang and Morris 2008). If this had been known and the shakes had been preservative treated, there might still be a pine shake industry in Alberta today.

2.2 Using Designs that Promote Biodeterioration

One of the most easily observable examples of dumb design is what I have come to call "the built to rot cedar fence" (Figure 1). Everybody will have seen this. The bottom of the fence is a 2 x 4 on the flat. Two nominal 1 x 1 inch strips are nailed or stapled at each edge leaving a slot into which the fence boards are dropped. A similar structure at the top holds them in place, at least until they start to get shorter. The reason they get shorter is that the eavestrough design of the bottom traps water, which wicks up the end grain taking the wood extractives with it. Deposition of extractives can be seen as a wavy dark band where the water evaporates. Low extractive content and moist conditions lead to decay at the bottom so when the board gets short enough it flops out of its frame. No wonder people consider using other materials reputed to be more durable. Designing these fences so they don't trap water would substantially increase their service life and perhaps maintain this market.

An example of dumb design that has affected me personally is discharging downpipes that have collected water from large pitched roofs onto small areas of slab, flat roof, or balcony, and expecting the water to find its own way to drain. Even worse is when the area slopes towards the building which was the case on the building where I live (Figure 2). The cedar deck on top of the slab was sitting in water for 9 months of the year. During the winter, warmth from the underground parkade would evaporate some of that water which would then condense on the underside of the deck boards. As a consequence the part of my cedar deck next to the building, where it was under the overhang of a balcony, unexpectedly rotted out faster than the part exposed to rain. That had me puzzled for quite a while. We have now put a sloped topping on the slab and run connections from the downpipe under the deck to the garden. Doing those simple things when the building was built would have saved a lot of money in repairs.

As another related example, our building downpipes were only 50 mm diameter and they were always getting plugged up with leaves. In coastal BC, we have a tree called the big leaf maple, which can have leaves 300 mm in diameter (Figure 3). We have now upsized those downpipes but it could not have cost a lot more to have put in the larger diameter in the first place.

One of the biggest causes of Vancouver's leaky condominium crisis was complex facades with water trapping design features (Ricketts 1997, Morris 2006). Because each building was essentially multiple similar units, these design features were repeated multiple times in one building. A poorly designed connection between a balcony guardrail and a wall might be repeated 100 times creating 100 points of entry for moisture. That is why decay in these buildings was so extensive and why the entire cladding had to be removed. By contrast, Vancouver has dozens of examples of large wood frame mansions around 100 years old with little or no decay. These had large pitched roofs with wide overhangs and small pitched roofs over porches or other extensions, lap siding or shingles with lots of drip edges and flared transitions between different claddings. One of the Vancouver developers coined the term umbrella architecture for this and it is now becoming more common again.

2.3 Using Poor Construction Methods

Leaving construction materials out in the open uncovered or worse, sitting in a puddle of water, is guaranteed to build moisture into a structure right at the outset. Allowing a partially built structure to get rain-soaked has the same result. If it is sealed on all sides with vapour impermeable materials, it can stay at a suitable moisture content for decay long enough for failure to occur in as little as two years. Wetted wood needs to be allowed to dry before the structure is closed in.

Even with the best design in the world, poor construction can create major moisture problems. Failure to slope surfaces to drains is one of the most commonly encountered. That is why many flat roofed industrial buildings have rooftop wading pools in operation for days after heavy rain. Eventually flat roofs always leak. Balconies and walkways are smaller scale areas where appropriate sloping is critical to long term durability. Problems in these areas were key contributing factors to Vancouver's leaky condominium crisis (Ricketts 1997).

It is not just horizontal surfaces that can collect water and channel it to a location where it can penetrate the building envelope. Windows channel all their water onto the window sill where some of it spills over the ends. This is a key location for potential moisture entry into walls and requires careful waterproofing. Failure to adequately waterproof windows was a key contributing factor to Vancouver's leaky condominium crisis (Ricketts 1997).

2.4 Using the Wrong Wood species

In our grandfathers' day they would never have considered using anything other than western red cedar or white cedar for wood components on the exterior of buildings, particularly fascia and trim. These days, painted Spruce-pine-fir (SPF) is commonly used in these applications. Paint can reduce moisture uptake but it can also retard drying of moisture that does get in. Most importantly, paint is not a preservative and untreated SPF is not sufficiently durable for exterior applications. Rotting window trim and fascia is going to be the next trend in building facades. Since the supply of cedar is limited and the price keeps going up, treated SPF may be the best alternative.

2.5 Using Untreated Wood where Treated Wood Should be Used

This is the most common mistake I see, and it is everywhere I look. Exterior stairs are the most egregious example, particularly those over a crawlspace coming down from a porch. Of all the places to skimp on cost, this makes the least sense. Decay typically occurs internally or on the underside and the first sign of problems is when somebody puts a foot through a stair tread.

Untreated glulam exposed to the weather on the exterior of buildings seems to be a favourite with west coast architects. They even win awards for these buildings. But you go back a few years later and you can see fungus fruitbodies popping out of the structure. Either these need to be completely protected by design, or they need to be substantially protected by design with application of borate/glycol surface treatments plus borate rods. If they are going to be fully exposed to the weather, they have to be made from lamina pressure treated with waterborne preservatives. After gluing only oil-based preservatives should be used for pressure treatment and these are only suitable for industrial applications such as bridge components.

There have been a number of examples of the collapse of untreated decks and balconies, usually in the middle of a party. It makes me want to slap a sticker on it saying "Should'a Had It Treated".

2.6 Using the Wrong Treatment

With the limitations on the use of CCA and the introduction of a broader range of preservatives, we are starting to see cases where the wrong treatment is used for the hazard. I know of a small footbridge over wires on a trail in Kauai that had just been built out of borate-treated wood when I was last there on vacation ten years ago. I will be going back in a few months to see how it is doing. Given the reputation of Kauai for rainfall, I suspect the borate may have leached out by now and the termites may be having a feast. (Note: it has been drawn to my attention that borate treated wood is probably the only type available in the stores in Kauai and very little treated wood is used outdoors).

2.7 Poor Treatment Processing

Some of the most effective preservatives ever developed will not work if the treatment processing is done poorly. In the early 1990s, pentachlorophenol treated southern pine poles were failing prematurely across Ontario and Quebec. The cause was pre-treatment decay in the seasoning yard (Morris and McAfee 1992). More recently, there have been increasing numbers of cases of full-length landscape timbers decaying after 12 to 15 years due to inadequate penetration with CCA because of lack of incising. Typically the treatment quality is not specified by the designer or he merely references CSA O80 without further qualification. This needs to change if we are to ensure that the right treatment is used for specific end uses. The new CSA O80 series 2008 using the Use Category system should help with this.

Inadequate penetration shows up a whole lot faster in southern climates. The American Wood Protection Association technical meeting in September 2009 was held in Wilmington, North Carolina. Along the river front, many of the CCA treated southern pine bollards on a boardwalk constructed only 3 years earlier (according to two locals) were showing fruitbodies of *Gleophyllum sepiarium* (Figure 4). That fungus does not grow well on heartwood so it seems likely that there was unpenetrated sapwood in this material. It really should be possible to fully penetrate the sapwood of southern pine.

2.8 Failing to use Treated Wood Properly

With Canadian wood species, even if the wood is properly dried, incised and pressure treated to meet CSA standards, a cross cut exposes unpenetrated wood vulnerable to decay. On small dimension products, this may be a limited enough area that the amount of mobile copper available on adjacent treated surfaces can provide protection (Choi et al 2004, Morris et al 2004). On 4 x 4s and larger sizes, cross cut ends will decay if not protected with a field-cut preservative. Failures of cut landscape timbers have been noted within 8 years in Vancouver and Whistler (Figure 5). Unfortunately field-cut treatments are rarely applied. That is mainly because the producers of wood preservatives and treated wood and the retailers do not do enough to educate consumers about the need for such treatment. It is also partly because copper-naphthenate is unpleasant to work with and difficult to clean up. Work is underway at FPInnovations to evaluate alternative water-borne field cut preservatives. Ideally these would be placed in the treated wood aisle in the big box stores and not next to the deck cleaners.

2.9 Failing to do Adequate Maintenance

All materials and structures need some level of maintenance and that requires the owner to at least do a cursory inspection every few years. The most dramatic example of lack of maintenance I ever saw was the picture on the front page of the New Orleans Times Picayune of a house that had literally fallen in half through being eaten by Formosan termites. You would have thought they could have at least heard the munching noises. Surveillance and remediation is particularly important when it comes to termite management (Morris 2000) but also applies to decay. Clearing away accumulated leaf litter and washing off moss and algae from shingle roofs, decks and other exterior structures facilitates drying. Regular application of a water repellent will considerably extend the life of a deck, not so much in terms of biodeterioration, but in terms of weathering leading to an unacceptable appearance.

3. Discussion

Everywhere I go I see examples of decay and termite damage caused by people doing dumb things with wood. Much of the time because nobody has told them the right thing to do. One step to rectify this was the development, ten years ago, of the www.durable-wood.com web site jointly run by FPInnovations – Forintek Division and the Canadian Wood Council. We have tried to put there most of the information people need to know to ensure wood structures remain durable. If you go there looking for something and it is not there, let us know. If we know the answer, we will get it on the site as soon as possible. If we don't know the answer, we probably know somebody that does. If nobody knows the answer, that is just fine because that is a research project and that keeps us in a job.

4. Conclusions

The biggest cause of decay and termite damage is people doing dumb things with wood.

To improve the reputation for wood as a durable material we need to better educate consumers.

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Figure 1. The Built-to-Rot Cedar Fence

Figure 2. Slab Sloping Towards Building

Figure 3. Small Pipes and Big Leaf Maples

Figure 4. Fruitbodies of *Gleophyllum sepiarium* on CCA Treated Southern pine after 3 Years

Figure 5 Cut Ends Without Field-cut Preservative Decaying in 8 Years in Whistler BC