Research Findings, Learning from Restoration/Preservation of an Historic House and Comments about Secretary of Interior Standards

Painting/Repainting Workshop
June 10, 2006
M.O. Hunt
Outline/Contents

Research Program
– Why a research program?
– Outline of the research
– Presentation of significant current results/findings
– Recommendations
Learning from actual restoring and preserving
– Problem with 13 yr. old wall construction in house addition
– Increased rot susceptibility of new growth yellow poplar
– Use of borate-based preservatives
– Paint damaged by hail
– To caulk of not to caulk
Two Case Study Houses – living research
My personal experiences. As founding chairman of the Wabash Valley Trust’s Historic Plaque Program I’ve had experience in assessing historic buildings’ qualifications to receive the historic plaque. In 1989 soon after formation of the program we focused on identifying qualifying buildings in downtown, specifically Main Street. The slide on the left shows the front façade of a florist at 5th and Main Streets less than 5 years after its façade was restored under the Main Street Program. The project received $35,000 in tax incentives and was judged to have met the Secretary of the Interior’s Standards for Rehabilitation. Unfortunately, money was wasted. I thought, surely wood material science and paint technology information could be assembled to make a project like this successful. The picture on the right is a sequence of photos showing the restoration of my house. During the project I couldn’t answer all of my own questions about what constituted best practices for wood material science and paint technology in restoration/rehabilitation.
Test specimens called exposure panels (17x24 in.) were designed and constructed to look like small-scale versions of actual façade panels seen on buildings along Main Street, USA. The exposure site is a secure area north of the Purdue Airport on the west edge of Purdue University campus. Literally, like building facades on Main Street in downtown Lafayette, Indiana, the panels are oriented due south with unobstructed exposure. In the early years, panels were assessed every 6 months according to a detailed inspection protocol. Later inspections were conducted on an annual basis. The last detailed inspection was done after 8 years of weathering. A computer database resulting in millions of observed performance results has been compiled.
Exposure Panel Construction

72 combinations of variables

• Wood: yellow poplar, western red cedar, dry CCA so. pine, wet CCA so. pine
• Panel design: 3 for a raised panel effect
• Surface pre-treatment: none, solvent-base WRP, water-base WRP
• Paint type: latex primer + latex top coats; alkyd primer + latex top coats
• Sealant (caulk): none, latex, urethane
• Paint color: white, medium gray

3 replications + others = 275 panels

Outline of fabrication of exposure panels.
Effects of Wood type and Paint type
Number of superior panels after 9-1/2 yrs.

<table>
<thead>
<tr>
<th></th>
<th>Alkyd</th>
<th>Acrylic</th>
<th>% by Wood type</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of panels</td>
<td>139</td>
<td>135</td>
<td>27</td>
</tr>
<tr>
<td>Yellow Poplar/Western Red Cedar Combo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>16</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Dry CCA southern pine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>96</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Wet CCA southern pine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>0</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>275</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>% by Paint type</td>
<td>12</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

All superior panels pretreated with water-repellent preservative (WRP)

In May we completed a “windshield” inspection. From an inspection distance of 6 ft., a rating of from 2 to 9 was assigned to each panel based on its overall appearance. Panels with a rating of 8 or 9 were deemed to be “superior.” Panels with these ratings would require no refurbishment if they were in actual use in a store front. Panels with ratings of 6 and 7 were classed as good, but would require repair/touch up paint for continued satisfactory service if they were in an actual storefront. This table summarizes construction details of panels rated as superior after 9-1/2 years of weathering. Overall the acrylic latex paint combination is better than the alkyd/latex combination. Interestingly, 1 out of 4 of the panels constructed with the yellow poplar/western red cedar combo of woods is still of superior grade. And 1 out of every 5 of the panels constructed from wet CCA southern pine are rated as superior. This is surprising. Bear in mind, southern pine is known not to hold paint well. Add to this that most of the southern pine is plain sawn/flat grain which makes paint performance even more problematic. Still further consider that this wood was painted while wet/damp; definitely, not recommended practice for any wood. But contrasting the performance between wet and dry CCA southern pine, wet is superior AND acrylic latex paint is essential for good paint performance on southern pine.

The importance of WRP is indicated.
Detailed inspections of the panels were conducted for 8 years. These graphs plot the change in the performance characteristics of paint cracking and paint flaking based on the consideration of the four wood types used in the construction of the exposure panels. The vertical axis of the graphs indicates the percent of panels with areas that are the same as when the panels were installed. When the panels were installed at the test site they registered 100%, that is no surface areas were blemished. As the surfaces weathering fewer surface areas maintained an unblemished appearance. For example, a reading of 40% means that 40% of the panels' surface areas were still pristine/unblemished while 60% of the surface areas had weathering-induced damage. We note that yellow poplar is about equal to western red cedar in paint performance.
Similarly, these graphs indicate the difference in weathering performance due to the two types of paint. Data shows that the acrylic latex is superior to the alkyd primer + latex top coats format.
Yellow Poplar/Western Red Cedar, WRP, acrylic latex primer, acrylic latex top coats

One of the superior rated panels. Would expect this panel to continue to provide excellent service for month/years to come.
Panel demonstrates the surprising performance of the combination of wet CCA southern pine with abundance of flat grain, acrylic latex primer and water-repellent preservative.
New-growth Yellow Poplar

- Dimensionally unstable - more warp
- Susceptible to rot

BUT remember paint performance on new-growth yellow poplar is good.

All the yellow poplar used to construct exposure panels was new-growth and predominately sapwood. It is known that heartwood of old-growth yellow poplar has a degree of decay resistance and resistance to termites. Sapwood, of new-growth yellow poplar would be expected to be susceptible to rot, AND IS IT EVER! Also in comparison to old-growth, new-growth yellow poplar is dimensionally unstable. BUT as shown earlier, paint performance on new-growth yellow poplar is about equal to western red cedar, the acknowledged standard for superior paint performance.
Indicative of new-growth yellow poplar’s dimensionally instability; it’s shrinkage is the same as wet southern pine, an unstable species (much of the southern pine is juvenile wood which is even more unstable than normal southern pine).
Joint Separation vs. Surface Pre-Treatment

The use of WRP greatly reduces the amount of opening between adjacent pieces of wood in a joint. This beneficial effect applies to all wood species in the study.
The panel on the left had no WRP pretreatment, whereas the panel on the right was pretreated with WRP. Paint performance for both panels would be expected to be poor; both are constructed with a preponderance of flat-sawn southern pine.
Rot in new-growth yellow poplar

Allocation of wood parts in this panel is yellow poplar in the top horizontal and left hand vertical members and western red cedar in the opposing parts.
Rot in new-growth yellow poplar

Rot observed in the top horizontal and left-hand vertical parts, which are yellow poplar.
Rot in New-Growth Yellow Poplar after 9-1/2 yrs.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-base WRP</td>
<td>6/44* = 13.6%</td>
</tr>
<tr>
<td>Solvent-base WRP</td>
<td>5/47 = 11%</td>
</tr>
<tr>
<td>No pretreatment</td>
<td>4/12 = 33%</td>
</tr>
</tbody>
</table>

* = No. of rot infected panels divided by total number of panels with that treatment

The WRP provides some protection, but obviously not complete protection. This is a problem.
After 9-1/2 years of weathering the first case of rot in western red cedar was observed. Rot was discovered in the end grain at the top of the right-hand vertical member, which is western red cedar. This is the same panel shown earlier with the advanced state of rot in the yellow poplar upper horizontal member. It is acknowledged that the rot in the cedar right hand vertical member is in close proximity to the heavily infected yellow poplar upper horizontal member.
Paint Color: Gray vs. White

Relative dark surface absorbs solar energy and white surface reflects solar energy.
Between 18 and 24 months of exposure, mildew completely overwhelmed both paint formats that were labeled as “mildew resistant.” Also note that the advertised mildewcide benefit of the WRP was short-lived.
Use ring-shanked nail, specify “right” kind of MDO (medium density overlay) BUT look at condition of paint.

In the category of I wish I had done something differently, I wouldn’t have used smooth shank, finishing nails (actually gun-fired nails). Also I should have better specified the medium density overlay plywood used as the vertical panel in all panels. The plywood did not have a balancing layer of resin-impregnated paper on the backside of the panel. It was of unbalanced construction – paper face layer bonded to a normal 3-ply plywood panel. The paper overlaid weathering face expands and contracts differently than the wood veneer back face resulting in the bowing shown above. The deformed MDO panel as shown above pried the face pieces off. We refer to this situation as the panel self destructed.
Guaranteed – NO ROT, NO Paint Problems
9-1/2 yrs. weathering

Here’s the solution! Only half in jest. Paint is not a preservative. If water gets behind the paint film it is trapped and held by the paint. This creates an ideal situation for rot to progress. In addition to here, it has been observed elsewhere that well-drained, unpainted wood seldom rots. It’s not pretty, but … .
Recommendations

- Lightly sand surface before pretreatment
- Pretreat with a **paintable** water-repellent preservative
- Use a quality paint system consisting of a 100% acrylic latex primer and two 100% acrylic latex top coats
- Use white or lightly colored paint
- Use ring-shanked nail


Lightly sanded surface provides better paint adhesion and also promotes a thicker paint film. The difference in paint performance due to surface texture/roughness can be noted in the relative paint performance of the old part of my house and the addition. The siding on the old house was stripped with the Paint Shaver then lightly sanded. The surface was rough. The siding on the addition had a hard surface created by planing. It was not sanded before painting.

The recommendations are largely based on results presented in the following research paper:

Learning from Restoring and Preserving

- Strip 160 yr. accumulation of paint, then use the recipe
- New-growth yellow poplar’s rot susceptibility
- New wall (13 yr. old) construction: house wrap and rain-driven rain
- Compared with original (160 yr. old) wall construction
- What to do?
- Lightly sand surface before WRP pretreatment and painting
Learning from Restoring and Preserving (cont’d.)

• Impel rods – diffusible borate rods
• Mildew’s preference for new-growth yellow poplar
• Hail damage
• Ease the sharp edges
• Caulking (sealant): To Caulk or Not to Caulk, that is the question.
• The three main causes of damage to materials and systems are?
In June of 1993 when the paint stripping project started, first chemical strippers were tried. Available was “Peel Away” (then consisting of a very high pH caustic paste) and methylene chloride. They were discontinued because of mess and slow production. In addition, Peel Away pulped the surface wood fibers. Next tried heat: heat plate and heat gun. Results of heat methods were much faster than chemicals but produced a surface consisting of glazed formerly melted paint pressed into the surface wood fibers. This surface had to be sanded before painting. The high surface temperature associated with this method liberated lead gas and sanding the surface produced lead paint particles. Both factors were health concerns for the operator, plus lead particles from the sanding were not contained. Also there’s fire danger associated with use of heat plate or heat gun. I actually started a fire with the heat gun. Finally, completed the stripping with a “Paint Shaver.” Paint fragments were captured by vacuum and collected in a shop vac, Operator must/should wear a lead filtering respirator when using any of these methods. With a light sanding after the use of the “Paint Shaver,” which is a circular grinding device with a vacuum head, a slightly roughened surface resulted which is ideal for painting.
Notice anything?

Note the nearly vertical, black mark midway along the bottom edge of the third strip of siding from the bottom.
The fissure across the grain of wood is the telltale sign of rot. This is verified by the knife sticking in the rot deteriorated wood. Note, other than the one crack there’s no paint problem. The paint actually encased the rotten wood along the drip edge of the siding.
When the deteriorated strip of lap siding was removed, extensive water stain on the TYVEK house wrap was obvious. Wall construction detail for the unheated garage (from inside out): studs 16 in. on center, plywood/OSB sheathing, TYVEK house wrap stapled to sheathing, yellow poplar lapped siding nailed to studs. Thus the backside of the siding was in direct contact with the housewrap. Note: the face, drip edge and most of the backside of each piece of yellow poplar siding was brush-coated with WRP.
Mycelium of the rot fungus on the face of the sheathing and the backside of the house wrap. This indicates liquid water had penetrated through the house wrap to wet the sheathing and create the conditions for rot. In contrast, house wrap allegedly does not allow penetration of water.
Rotted original band board and its replacement. The original board had been back-primed with WRP. This indicates that the preservative benefit of WRP is of short term benefit, at best. The replacement is yellow poplar that was face-primed with WRP (to promote superior paint performance) and back-primed with BoraCare. BoraCare is water-soluble borate preservative.
Where's the water coming from? Installing kraft paper against house wrap before reinstalling siding

The strip of kraft paper was to act as an indicator strip for water penetration.
Screws were used instead of nails in reinstalling the siding. This would facilitate removal and re-inspection in the future.
Oct. ’05 – May ’06: Stained by wind-driven rain

After less than 8 months, the siding is removed, and evidence of major water penetration is obvious. This would indicate that wind-driven rain is the principal cause.
Migration of borate corresponding to water stain pattern on kraft paper

Borate is water soluble. There appears to be so much water that the borate that had been brushed on the surface has been washed out. For perspective, the top of the board is the drip edge.
There’s no evidence of rot of siding on the old house, either old siding or the few replacement pieces of new-growth yellow poplar. What’s different between the addition wall construction and that of the old house? The wall construction of the old house, from inside out, consists of horse-hair plaster interior walls, essentially open stud cavity, and siding nailed directly to the studs. As this picture shows there are many gaps between overlapped siding. Therefore, the stud cavity is well-ventilated. Water that is driven behind the siding can drive relatively quickly. Thus water is not held against the backside of the siding as is the case in the new construction.
If I had it to do over, I’d definitely use a rain screen type of wall construction.
Weathering of paint on new yellow poplar siding with western exposure after 13 years (w/o benefit of a slightly roughened surface)

Photo shows weathering of paint on new siding on garage with a western exposure. Some similar wear spots, especially near drip edge on new siding on southern exposure of garage. No such wear observed on siding on old house with similar exposures. Suggest the principal difference is that the surface of old siding was in roughened condition after mechanical removal of paint. Whereas the new siding was manufactured by resawing planed boards and using the planed surface as the exposure face of the siding. The planed surface was hard and smooth. Slightly roughened surface is best for paint performance.
Impel - diffusible borate rod

Left picture, upper part of butt joint shows black stain. This is beginning of rot in end grain of new-growth yellow poplar. To remedy, an Impel rot is inserted in the problem area. The adjacent butt joint was re-caulked to prevent additional water intrusion.
Mildew’s preference for new-growth yellow poplar

A side-by-side comparison. The bottom four courses of siding are new-growth yellow poplar replacement siding on the old house; they are liberally covered with mildew. The topmost course is original, old-growth yellow poplar siding. It is free of mildew. In general, the original, old-growth yellow poplar siding is free of mildew after 12-13 years of exposure. Treatment of new siding and old siding was exactly the same.
Hail stones resembling solid spheres impact the painted surface rupturing the paint film. Subsequently, water penetrates the cracks causing an expansion of paint film deterioration.
Ease sharp edges

Sharp edges, such as on this windowsill, have early paint failure. Paint accumulation on a sharp edge is very minimal. Slightly round the sharp edges to increase surface area so an adequately thick paint film can be applied.
Improper selection of material

What do you see wrong? What's the streaking in the white painted façade panels?
For gosh sakes, it can’t be! But it is - regular construction plywood painted and exposed to the weather. Guaranteed, paint is going to literally fall off the bands of summerwood and crack along lathe checks. MDO, with paper overlay on both faces of panel should have been used. Solution to this problem, is to replace with MDO.
Bottom of corner pilaster. The 160 old-growth yellow poplar wood is rotting. Water is being trapped behind the paint film and sealant/caulk. Don’t know if water is leaking through small cracks in sealant/caulk. Holes for implanting four Impel rods are shown. The holes will be covered.
The three main causes of damage to building materials and systems are …

• WATER
• WATER
• WATER
There is interest in jointly considering the Secretary of Interior’s Standards for Rehabilitation and best practices for wood material science and paint technology (such as discussed here)
SOI Standards have stressed gentlest method of surface preparation to minimize damage of the historic fabric.

There's now discussion that surface preparation should be gentlest but sufficient to optimize paint life and performance.

Balancing between damaging historic fabric and having cost effective paint performance. Don’t need to invite the vinyl salesman.
1307 Columbia Street
Paint Removal Demonstration
602 N. 5th Street
Case Study House
400 S. 7th Street
Case Study House