TWO-STEP OVERLAY PROJECT USING THE LABORATORY PRESS

By

Kenneth Roos
Associate Scientist

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Natural Resources Research Institute
University of Minnesota, Duluth
5013 Miller Trunk Highway
Duluth, MN 55811

INTRODUCTION

The purpose of this project was to assess the potential use of a resin impregnated paper overlay on commercially manufactured structural flakeboard. While paper overlays have been used for some time in the plywood industry, it was felt that the cycle times could be reduced for use in the flakeboard industry. Some work has been done with potential uses of paper overlays in the OSB industry; there is some current use of paper overlays in one-step processes for siding products. The objectives of this study were: 1) to establish a set of forming parameters for the overlaying of structural flakeboard with paper overlays in a two-step process, and 2) development of a potential product for overlaid panels, i.e. concrete forms. The paper overlays evaluated for manufacture of concrete forms were two phenolic based papers and one melamine based paper.

The pressing parameters evaluated for this study were temperature and time. The pressure was held constant at 200 psi. Control panels were overlaid at 300°F for 4.5 minutes, a typical cycle time used in overlaying of plywood. The original plan was to increase the temperature to 350°F and press for 4.5, 4.0, and 3.5 minutes; then increase the temperature another 50° to 400°F using the above press times if the results of 4.5 and 4.0 minutes were positive, otherwise the press times for 400°F would be dropped down to 4.0, 3.5, and 3.0 minutes.

While the pressing of the control panels went according to plan, modifications to the other two group schedules was necessary. When the temperature was increased to 350°F, and the panels pressed for 4.5 and 4.0 minutes, blows occurred regularly and the surface of the overlay exhibited many areas where flakes rose through the surface of the paper. Therefore, the times were dropped to 3.5, 3.0, and 2.5 minutes. At 3.5 minutes one panel out of nine blew and most of the others had some minor flake rising, but this seemed to go down and the surface became smooth again after hot stacking. The other two times for 350°F seemed to work out well.

More problems were encountered when the temperature was raised to 400°F. At both 2.5 and 3.0 minutes of press time the panels were blowing severely. Times were dropped to 2.0 and 1.5 minutes, and while blows were reduced, some minor flake rising was evident at these two press times. The press time was not dropped any lower because of concern that the B-stage cure in the paper would not set. The blowing of the overlay panels is probably due to the moisture in the panel becoming superheated, and turned into steam under the high temperatures and long press times. There is so much built-up pressure present in the panel that it blows when the press is opened. The paper overlays make this condition even worse by establishing a water resistant surface layer on one side of the panel which prevents the steam from escaping from the panel when the press is opened. This is the most likely cause of flake visibility through the paper which go down once the steam pressure is reduced and equalized in the panel when hot stacked.

RESULTS

The panels were evaluated for overlay adhesion to the substrate and suitability for concrete form use. This was done by assessing the strength, durability, and dimensional stability of the panels. Strength was evaluated using the standard ASTM bending test for flakeboard (Table 1). Four samples per panel were tested; two along and two across the panel. No irregularities were found to exist along or across the panels which would dictate them being treated separately for analysis between paper types, time, and temperature; therefore the two groups of bending samples were analyzed together. From the results of the bending test, no evidence was found to exist that there is any significant difference ($P<0.05$) in the strength of the panels due to the different combinations of overlay type, length of press time, or temperature. However the control panels did have an average modulus of rupture slightly higher, 135 psi, than the other two groups of panels overlaid at a higher temperature.

Table 1.--Modulus of rupture, values for various combinations of forming parameters in two-step overlaying of OSB.

Paper[1]	Temp (°F)	Time (min.)	N	Mean (psi)	SD (psi)
P1	300	4.5	20	3654	1078
P2	300	4.5	20	4024	1347
M	300	4.5	19	3929	1606
P1	350	2.5	12	3887	1212
P1	350	3.0	12	3870	1240
P1	350	3.5	12	3749	1339
P2	350	2.5	12	3550	1160
P2	350	3.0	12	3610	1022
P2	350	3.5	12	4020	1157
M	350	2.5	12	3642	1016
M	350	3.0	12	3719	962
M	350	3.5	11	3573	1352
P1	400	1.5	12	3819	1433
P1	400	2.0	12	3542	1432
P2	400	1.5	12	3628	1162
P2	400	2.0	12	3891	959
M	400	1.5	12	3894	1053
M	400	2.0	12	3633	1442

[1]Notes:

- P1-Panels overlaid with phenolic based paper number one.
- P2-Panels overlaid with phenolic based paper number two.
- M-Panels overlaid with melamine based paper.

The mean for the control group, 300°F, is . . . . 3869 psi
The mean for group two, 350°F, is . . . . 3735 psi
The mean for group three, 400°F, is . . . . 3735 psi
The mean for all possible combinations across the panel is . . . . 2742 psi
The mean for all possible combinations along the panel is . . . . 4761 psi
The overall mean for all possible combinations is . . . . 3769 psi

Earlier work with overlaid OSB panels showed a loss in strength when the panels were repressed. However the loss in strength is recovered by the addition of the paper overlay to the OSB, and the panels tested in this study had strength equal to or slightly better than samples tested that were not repressed.

The bending tests done on the overlaid panels suggest that adequate adhesion of the paper overlay to the substrate was achieved and there appears to be sufficient strength in the panels for concrete forms.

Durability was assessed two ways, one being APA test method F-4, Overlay Performance on Wood-Based Siding, and the other being the use of accelerated aging in a xenon-arc weatherometer. Only the control panels were sent through the weatherometer. While the weatherometer is good for accelerated age testing, it is very time consuming and expensive to run. The APA test method for durability is quicker, harsher on the panels, and yields as good if not better results on overlay adhesion.

The weatherometer was used to simulate long-term exposure to concrete curing with a constant temperature of 110°F and wetting of the panels on the paper side for 18 minutes every two hours. The samples were in the weatherometer for a total of 400 hours, after this amount of time they were evaluated for overlay adhesion, surface cracking, and surface distortion. Five samples of each paper type from the control schedule were run through the weatherometer. No delamination or surface checking was found to exist in any of the samples after 40 hours. The only surface distortion exhibited on the samples was around the edges, and this was evident in all of the samples. This probably could be minimized by edge sealing, however, the weatherometer did result in discoloration of the paper overlay over time. The phenolic based overlays turned darker in color and the melamine surface bleached to a white/beige color. The results obtained from the weatherometer suggest that the overlaid panels will perform well under conditions of long-term exposure to heat, high intensity light, and sporadic moisture.

The APA durability test proved quite useful in assessing overlay adhesion to the OSB. The samples were run through three cycles of the durability test. This consisted of a water soak with a vacuum/pressure schedule and drying in a forced-air oven at 145°F for 20 hours. The control panels after three cycles showed no evidence of delamination or surface checking of the overlay. The same results were obtained with the samples overlaid at 350°F. However after three cycles the panels overlaid at 400°F for 1.5 and 2.0 minutes showed negative results. The melamine overlay seemed to tear easily; this was more pronounced in the 1.5 minute panels than in the 2.0 minute. It appears the resin in the paper did not cure totally during these short press times. The phenolic based papers did not exhibit this tearing of the overlay. All three paper types at 1.5 and 2.0 minutes showed delamination of the paper from the substrate after three cycles of the test. As with the tearing in the melamine, this was more pronounced in the shorter press time than the longer one. This suggests that pressing longer than two minutes must be used for overlaying OSB with resin impregnated paper overlays to provide good durability.

The APA durability test demonstrated that panels can be overlaid adequately at both 300° and 350°F with the press times used. However, 400°F should be avoided since the shorter press times provide insufficient paper curing and adhesion to the substrate and when longer pressing times are used the panel is subject to blows and severe flake rising on the surface.

Dimensional stability was measured using two different tests. The ASTM thickness swell and water absorption test was used to evaluate the effect of high temperatures and press times on the spring back, i.e. swelling of the panel. A modified version of the APA wetting on one side test was used to evaluate the water resistance of the paper when continuously wetted on one side for seven days.

The ASTM test showed that repressing the panels does result in significantly higher swelling and water absorption of the panels when submerged for 24 hours (Table 2). The type of overlay used did not affect the amount of swelling or water absorption; therefore the paper types were grouped together for analysis. Within the 300° and 350°F groups, the length of press time did not affect the amount of swelling or water absorption, but in the 400°F group, the 2.0 minute panels did swell significantly more than the 1.5 minute panels. This is probably due to less panel compression in the shorter cycle.

It was determined that the higher temperatures significantly affected the amount of swell and water absorption. Also, the longer press times dried the panels to a significantly lower post pressing moisture content, but this did not affect the dimensional stability of the panel significantly. Therefore, thickness swelling and water absorption is more a function of temperature than press time. This further confirms the need to avoid temperatures such as 400°F. While the increase in swelling between the panels overlaid at 300° and 350°F was significant in this study, the actual amount is only 0.030 inches on average. This should not affect the performance of these panels for use as concrete forms.

The modified APA test revealed some of the most dramatic results of this study so far when control panels (overlaid at 300°F, 200 psi, 4.6 min.) were tested (Table 3). The paper overlay was found to significantly reduce the amount of swelling and water absorption of the panel when subjected to a constant spray for seven days. The non-overlaid panels swelled over three times as much and absorbed over five times as much water as the overlaid panels. There was no significant difference between the types of paper used for water absorption and thickness swell, but the phenolic based papers did perform better than the melamine based paper in this respect. Phenolic paper #1 swelled 0.015 inches less and absorbed 4.188 grams less water than the panels overlaid with the melamine based paper. Phenolic paper #2 was about half-way between the two. While this does not seem like a large difference, it had a major impact on the surface texture of the panel after seven days. The panels overlaid with the melamine based paper had more rises in the surface compared to the phenolics which could and probably would make it a undesirable concrete form.

The addition of a paper overlay makes the panels significantly ($P<0.05$) better in water resistance; therefore, exhibiting better dimensional stability. There was no significant difference between the types of paper used but the melamine based overlay did allow more water through and this caused the surface texture of the panel to become uneven from flakes rising through the surface.

Table 2.--Mean values for swell and water absorption test between various forming parameters of overlaid OSB.[1]

Temp (°F)	Time (min)	N	Swell (inches)	Wt Gain (grams)	Original % MC	Final % MC	Percent Swell
0	0	10	0.08	58.7	4.40	29.9	11.3
300	4.5	29	0.11	68.5	3.17	30.8	17.1
350	2.5	18	0.14	89.1	2.26	37.9	21.5
350	3.0	17	0.14	87.9	2.03	37.4	23.2
350	3.5	18	0.14	80.5	1.60	33.9	21.9
400	1.5	17	0.11	82.1	2.73	36.0	17.0
400	2.0	18	0.14	89.0	2.83	38.7	21.3

[1]Notes:

- Paper types were grouped together for this analysis.
- Temperature 0 and Time 0 were non-overlaid, non-repressed samples that served as comparisons in this analysis.
- The overlaid panels significantly ($P<0.05$) swelled and absorbed more water than the non-overlaid panels. Also it was found that the panels pressed at 350° and 400°F swell and absorbed water significantly ($P<0.05$) more than the panels overlaid at 300°F.
- The mean swell for all times of group two, 350°F, is 0.144, 22.22% of the original thickness.
- The mean swell for all times of group three, 400°F, is 0.129, 19.26% of the original thickness.

Table 3.--Average results of the modified APA test of wetting on one side - control group and non-overlaid samples.

Paper	Swell inches	% Swell of of Original Thickness	Grams of Water Absorbed	% Of Original Weight Absorbed
Phenolic 1	0.014	2.10	6.454	2.48
Phenolic 2	0.017	2.47	7.922	2.90
Melamine	0.029	4.38	10.642	3.97
Non-Overlay	0.095	13.48	58.829	22.76

Notes:

- This control group was overlaid at 300°F, at 200 psi, for 4.5 minutes.

CONCLUSIONS

The conclusions that can be drawn from this study are as follows:

- OSB can be overlaid in a two-step process successfully using all three paper overlays tried.

- Repressing OSB panels at 200 psi decreases the strength of the panel, but the addition of an overlay compensates for the decrease and may even make the panel stronger.

- The panels overlaid at 300° and 350°F were very durable, while those overlaid at 400°F were not.

- Repressing the panel significantly increases the thickness swell of the panel, this is due to the increased spring back encountered.

- Higher temperatures increase the thickness swelling of the panels. Longer press times at the same temperature produce a significantly lower post pressing moisture content, however, it does not seem to affect the dimensional stability of the panel significantly.

- The addition of a paper overlay to OSB makes it significantly better in water resistance, making the panel much more dimensionally stable when wetted on one side.

- The end use of the product has to be assessed before overlaying to determine if the type of paper chosen will give the results needed to make the overlaid panel perform adequately.

- The phenolic overlays are more resistant to water penetration than the melamine based paper and are therefore better suited for potential concrete form.

- The recommended schedule overlaying OSB developed from this experiment is: 200 psi, 350°F, and a press time of 3.0 minutes.

- Slight modifications of the pressing schedule may have to be made based upon the moisture content of the OSB panel being used; a more conservative schedule may be appropriate.