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January 25,2008

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TEST REPORT NUMBER:	DATE OF TESTING	MANUFACTURE PLANT
28005r1	1/21/2008 & 1/24/2008	N/A

SCOPE OF TESTING

ASTM D7032 "Establishing Performance Ratings for Wood-Plastic Composite Deck Boards and Guardrail Systems"

PRODUCT IDENTIFICATION

- **WorthingtonStone™** 0430 Top Rail
- **WorthingtonStone™** 0430 Bottom Rail
- **WorthingtonStone™** 0210-30 Port Royal Balustrade
- **WorthingtonStone™** NPP Newel Post
- **WorthingtonStone™** PC-1 Newel Cap
- **WorthingtonStone™** ½" Spacers
- **WorthingtonStone™** Spring Loaded Pins
- **WorthingtonStone™** 2in wide Wall Plate
- **Hoover Treated Wood Products** Exterior Fire-X ® nominally sized 2x4
- 5/8 in. Exterior Gypsum Wall Board
- ½ in. Plywood
- ¾ in. Pressure Treated Plywood
- Nominally Sized 2x10 Lumber
- No. 4 Rebar (1/2 in.)
- **Commercial Grade Quickcrete** 5000 High Early -Strength Concrete Mix
- **Commercial Grade Quikcrete** Crack Resistant Concrete Mix
- **Sika** Anchor Fix-3 Anchoring Epoxy
- ½ in.Galvanized Threaded Rod, Washers and Nuts
- Supplied ¼ in. Plate with No.3 (0.375 in.) Rebar
- Supplied 1/8 in. Plate without Rebar
- Galvanized 1/2in. x 5in. Bolt, Nuts and Washers
- Liquid Nails

PROCEDURE

Two (2) test specimens were constructed and tested by Cerny and Ivey Engineers, Inc. laboratory personnel. One (1) specimen was constructed on a wood deck mock-up and the other (1) was constructed on a structural slab mock-up.

Wood Deck Mock Up

A wood deck was constructed using nominally sized 2x10 lumber. The front and edges were constructed as a 4 ½" wide "triple beam" using three (3) 2x10s side by side. Two (2) additional 2x10s were attached at the inside corner of the triple beam, oriented so that nominal 10in. board face was facing up, to create blocking for the attachment of the newel post. Two (2) 2x10s were installed to the inside of the blocking, on each side of the assembly, in the same orientation as the triple beam. Intermediate 2x10 supports were installed to support the weight of the concrete. The size and spacing of these supports in the field needs to be specified by the appropriate design professional. ¾ in. plywood was attached to the top of the assembly

The plate with welded rebar was placed on top of the plywood so that the edges of the plate were 1 ½ in. inside of the edge and over 2/3 of the triple beams. This allowed three (3) lag bolts to penetrate the middle member of the triple beam and hold the plate in place. The remaining corner of the plate was secured using a 5in. bolt which passed through the 2x10 blocking below to the plate without the welded rebar. Once the plates were securely attached a form was created to pour a 2in. thick topping slab over the plywood using the water saturated Crack Resistant Concrete Mix. The assembly was secured to the test frame to insure that there was no rotational or linear movement. The newel post was placed on top of the rebar and aligned with the corner of the deck. The bottom third of the newel post was filled with the water saturated Crack Resistant Concrete Mix. The concrete was manually vibrated and allowed three (3) days to cure before any testing was commenced.

The newel posts were tied back into wood blocking with threaded rod. Four (4) 2x4s were connected side by side and connected to the test frame behind the newel posts. The 2x4s were oriented so that the nominal 2in. dimension was facing the newel post and the length of the boards was perpendicular to the deck. Two (2) pieces of 5/8in. exterior grade gypsum board were secured to the 2x4 blocking. One (1) piece of 1/2in. plywood was secured to the exterior grade gypsum wall board. The 2in wall plate was secured to the blocking using three (3) lag screws at the top of the plate and two (2) lag screws at the bottom of the plate. Please see Sections B-B and C-C for clarification of the lag screw spacing.

Holes for the top rail and bottom rail were drilled in the newel post and wall plate to accommodate spring loaded pins at opposite corners of the rail. Construction adhesive was placed in each of the holes. The spring loaded pins were placed in the bottom rail for installation. The rail was pushed into place so that the spring loaded pins aligned with the holes. The balustrades were placed in holes on the bottom rail and the top rail was pushed into place in a similar manner to the bottom rail. The installation of the rails was repeated for each side of the assembly.

The threaded rod was then inserted into the top rail through the blocking and secured with the appropriate nut to the inside of the newel post and the inside of the wall plate.

Structural Slab Mock Up

Three (3) 5/8in holes were drilled into the structural slab of the testing laboratory at each end of the railing assembly. Please see Section A-A for clarification of the rebar spacing. The holes were cleaned and filled with the anchoring epoxy. No. 4 rebar was inserted into the epoxy filled hole, leveled and allowed to dry for 24 hours. After 24 hours the newel posts were placed over the rebar. The distance between the posts was verified to be 144 3/8" (12ft. rail plus 3/16in tolerance at either end). The bottom 1/3 of the newel post was filled with water saturated Crack Resistant

Concrete Mix. All concrete was manually vibrated and allowed to cure for at least five (5) days before any testing was commenced.

Holes for the top rail and bottom rail were drilled in the newel post and wall plate to accommodate spring loaded pins at opposite corners of the rail. Construction adhesive was placed in each of the holes. The spring loaded pins were placed in the bottom rail for installation. The rail was pushed into place so that the spring loaded pins aligned with the holes. The balustrades were placed in holes on the bottom rail and the top rail was pushed into place in a similar manner to the bottom rail.

Application Of The Load

Three separate loads were placed on the railing system to simulate the conditions set forth in the 2006 International Building Code with a factor of safety of 2.5.

The initial load applied to the railing assembly was an in-fill load to the weakest 12in. x12in. section of the railing system. The weakest area was determined to be the center of the balustrades near the center of the assembly. The infill load was offset from the center slightly, so that two (2) balustrades would be impacted in lieu of three (3). A 125lb load was applied.

The second load was applied uniformly to the top rail of the assembly. The top rail was determined to be the weakest component of the assembly. Pneumatic cylinders were placed approximately every 12in, as dictated by the spacing of the balustrades. A load of 180plf was applied at an angle of 45 degrees to provide a minimum of a 125plf horizontal and vertical component.

The third load was a concentrated load applied to the top rail at the center of the assembly. The top rail was determined to be the weakest component of the assembly. A 500lb load was applied.

All loads were applied in the outward direction. All handrail testing was done in accordance with ASTM D7032.

Pull-Out Test

One (1) 12 in. test specimen was cut from the top of a newel post for pull out testing with test apparatus CI-ULM-01. A ½ in. hole was drilled in the center of the length where a ½ in. grade 8 bolt was placed with a washer. The test specimen was secured, while the test apparatus pulled the bolt and washer through the hole. The washer had an outside diameter of 1.375in., an inside diameter of 0.569in. and a thickness of 0.078in. All measurements were verified with measurement caliper, CI-OP-01.

Calculations were based on test results and the 2005 National Design Specification for Wood Construction ASD/LFRD.

RESULTS

Handrail Testing

Handrails passed all loading tests without any visible signs of failure. Deflection was minimal.

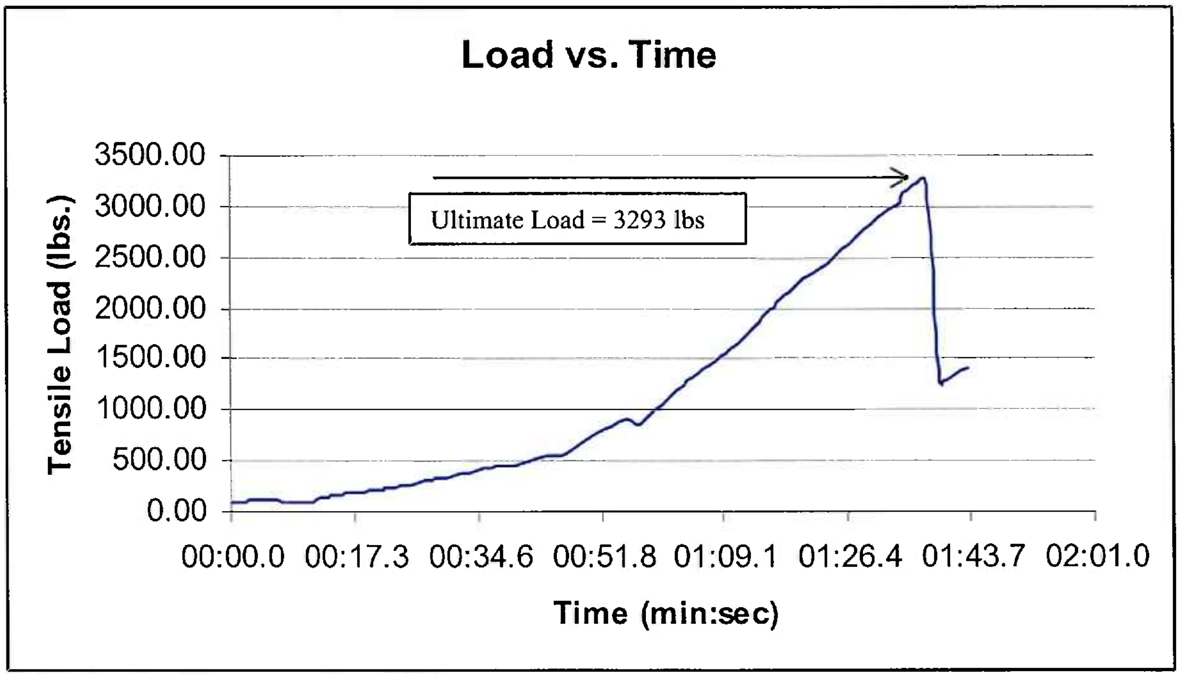
Wood Mock-Up (Tested 1/25/2008)

		2006 IBC	Passed (Y/N)		ASTM D7032 (F.S. 2.5)	Passed (Y/N)
In-Fill Load		50 lbs/ft^2	Y		125 lbs/ft^2	Y
Uniform Load		20 plf	Y		50 plf	Y
Concentrated Load		200lbs	Y		500lbs	Y

Concrete Mock-Up (Tested 1/21/2008)

		2006 IBC	Passed (Y/N)		ASTM D7032 (F.S. 2.5)	Passed (Y/N)
In-Fill Load		50 lbs/ft^2	Y		125 lbs/ft^2	Y
Uniform Load		20 plf	Y		50 plf	Y
Concentrated Load		200lbs	Y		500lbs	Y

Pull Out Test



Design Load = Ultimate Load/Factor of Safety = 3293 lbs./2.5 = 1317 lbs.

ENGINEERING CALCULATIONS

The withdrawal design values for various lag screws were calculated in accordance with the 2005 National Design Specification for Wood Construction ASD/LRFD (2005 NDS). For conformance with ASD (Allowable Stress Design) and LRFD (Load and Resistance Factor Design), Table 10.3.1 of the 2005 NDS indicates that the withdrawal loads shall be corrected with the following factors:

C_M = Wet Service Factor (Section 10.3.3/Table 10.3.3, 2005 NDS) = 1.0, assuming that the wood has a moisture content of ≤ 19% and is used under continuously dry conditions.

C_t = Temperature Factor (Section 10.3.4/Table 10.3.4, 2005 NDS) = 1.0, assuming that the wood will be exposed to a sustained temperature less than 100°F.

C_{eg} = End Grain Factor (Section 11.5.2, 2005 NDS) = 1.0, assuming that the lag screw is not being used in the end grain of the lumber.

C_{tn} = Toe Nail Factor (Section 11.5.4, 2005 NDS) = 1.0, assuming that a toe-nail connection is not used.

C_{ft} = Fire Retardant Treatment (Section 10.3.5, 2005 NDS) = 0.90, assuming that the wood is Hoover Treated Wood Products Exterior Fire-X ® (Data Sheet Attached)

W = Design Withdrawal Load (Table 11.2A, 2005 NDS)

Additional required information,

G = The specific gravity of the wood being used (Table 11.3.2A, 2005 NSD) = 0.55, assuming the wood is Southern Pine.

F.S. = Factor of Safety = 2.5

To find the corrected withdrawal load the following equation is used.

$$W' = (W/F.S.) \cdot C_M \cdot C_t \cdot C_{eg} \cdot C_{tn} \cdot C_{ft} = (W/2.5) \cdot (1.0 \cdot 0.8 \cdot 1.0 \cdot 1.0 \cdot 0.9)$$

or

$$W' = 0.72(W/2.5)$$

Withdrawal load is based on the values in Table 11.2A (2005 NDS), which are defined in pounds per inch of thread. The effective thread length does not include the tapered tip. Values for this length can be found in Appendix L of the 2005 NDS. Based on the 2005 NDS and standard lag screw sizes (Appendix L) that can be used in a nominal 2x4, the following table shows the withdrawal loads for different lag screws. All calculations assume that the 2x4 is providing all of the resistance to withdrawal and that no resistance is from the wall plate, exterior gypsum wall board or the stucco finish.

Table 1: Lag Screw Withdrawal Loads

Lag Screw Dia. (in.)	Lead Hole Size (in.)			Lag Screw Length (in.)	Lag Screw Effective Thread Length (in.)	Withdrawal Load (lbs.)	Corrected Withdrawal Load (lbs.)	2 Bolt Configuration	3 Bolt Configuration
1/4	3/20	to	3/16	5	19/32	154	56	111	167
1/4	3/20	to	3/16	6	1 19/32	414	149	298	448
1/4	3/20	to	3/16	7	2	520	187	374	562
5/16	3/16	to	15/64	5	9/16	173	62	124	187
5/16	3/16	to	15/64	6	1 9/16	480	173	345	518
5/16	3/16	to	15/64	7	2	614	221	442	663
3/8	9/40	to	9/32	5	17/32	187	67	135	202
3/8	9/40	to	9/32	6	1 17/32	539	194	388	582
3/8	9/40	to	9/32	7	2	704	253	507	760
7/16	21/80	to	21/64	5	15/32	185	67	133	200
7/16	21/80	to	21/64	6	1 15/32	580	209	418	627
7/16	21/80	to	21/64	7	2	790	284	569	853
1/2	3/10	to	3/8	5	7/16	191	69	138	206
1/2	3/10	to	3/8	6	1 7/16	628	226	452	678
1/2	3/10	to	3/8	7	2	874	315	629	944
5/8	3/8	to	15/32	5	11/32	177	64	128	192
5/8	3/8	to	15/32	6	1 11/32	693	250	499	749
5/8	3/8	to	15/32	7	2	1032	372	743	1115
3/4	9/20	to	9/16	5	1/4	148	53	107	160
3/4	9/20	to	9/16	6	1 1/4	740	266	533	799
3/4	9/20	to	9/16	7	2	1184	426	852	1279
7/8	21/40	to	21/32	5	5/32	104	37	75	112
7/8	21/40	to	21/32	6	1 5/32	768	276	553	829
7/8	21/40	to	21/32	7	2	1328	478	956	1434
1	3/5	to	3/4	5	1/16	46	17	33	50
1	3/5	to	3/4	6	1 1/16	780	281	562	842
1	3/5	to	3/4	7	2	1468	528	1057	1585
1 1/8	27/40	to	27/32	6	31/32	777	280	559	839
1 1/8	27/40	to	27/32	7	1 31/32	1579	568	1137	1705
1 1/8	27/40	to	27/32	8	2	1604	577	1155	1732
1 1/4	3/4	to	15/16	6	7/8	760	273	547	820
1 1/4	3/4	to	15/16	7	1 7/8	1628	586	1172	1758
1 1/4	3/4	to	15/16	8	2	1736	625	1250	1875

CONCLUSIONS

The test results for the pull out capacity of the column show that failure occurred at 3293 lbs. The failure was caused by a crack in the test specimen over the length of the specimen. With a factor of safety applied the design pull out load for the newel post is 1317 lbs with a ½ in. fastener.

The available data for the lag screws shows the maximum design withdrawal load that can be achieved is 388 lbs. with one (1) 3/8 in. x 6in. lag screw. In the case of the proposed handrail assembly (see Section B-B) the maximum design load is 582 lbs. with three (3) 3/8 in. x 6 in. lag screws.

The complete handrail assemblies are in accordance with the 2000 & 2006 International Building Code, as well as having satisfactorily passed ASTM D7032.

If you have any questions please don't hesitate to contact us.

Respectfully submitted,

Charles G. Lester IV
Laboratory Manager

Phillip L. Chapski, P.E.
Senior Staff Engineer

GEORGIA REGISTERED No. 14199 PROFESSIONAL ENGINEER PHILIP L. CHAPSKI

Figure 1: Data Sheet from Lumber Manufacturer

EXTERIOR FIRE-X™

FIRE RETARDANT TREATED LUMBER AND PLYWOOD ENGINEERING DATA

The following design value adjustments and plywood span ratings should be utilized for EXTERIOR FIRE-X:

DESIGN VALUE ADJUSTMENTS FOR EXTERIOR FIRE-X LUMBER

The adjustments tabulated below apply to EXTERIOR FIRE-X fire retardant treated southern pine lumber which bears the grademark of an ALS approved lumber grading or inspection agency and is used in the following conditions of service:

A In non-roof system applications where the ambient temperature does not exceed 125° F. **OR**

B As framing members in roof systems where

(1) Lumber temperature does not exceed 150° F, and

(2) Ventilation is evenly distributed, provides a uniform air flow over all interior roof surfaces, and is sufficient to effectively remove moisture when the roof system is warmed by solar radiation.

Property	Adjustment Factor
Extreme fiber in bending	.85
Tension parallel to grain	.80
Horizontal shear	.90
Compression perpendicular to grain	.90
Compression parallel to grain	.90
Modulus of elasticity	.90
Fastener/connector design loads	.90

For special applications where structural members may exceed a temperature of 150° F, contact Hoover Treated Wood Products, Inc. at 800/TEC-WOOD or 706/595-5058.

SPAN RATINGS FOR EXTERIOR FIRE-X PLYWOOD

The following plywood roof sheathing and subfloor spans apply to span-rated plywood and/or plywood bearing the trademark of an approved inspection agency, treated with EXTERIOR FIRE-X fire retardant where roof system ventilation is evenly distributed, provides a uniform air flow over all interior roof surfaces, and is sufficient to effectively remove moisture when the roof system is warmed by solar radiation.

Panel Thickness (in.)	Untreated Span Index Rating	Exterior Fire-X Max. span (in.)	
		Roof Sheathing (1, 2, 3, 5)	Subfloor (2)
11/32, 3/8	24/0	— —	— —
15/32, 1/2	32/16	24	16
19/32, 5/8	40/20	32	20
23/32, 3/4	48/24	40	24
7/8 (4)	— —	48	24

(1) Clips, blocking or other edge supports must be used with roof sheathing.

(2) Maximum roof load: 10 psf DL, plus 40 psf LL Maximum floor load: 10 psf DL, plus 100 psf LL

(3) For flat roof applications, call Hoover Treated Wood Products, Inc. at 800/TEC-WOOD or 706/595-5058.

(4) Limited to 7/8" CDX plywood made with Group 1 species.

(5) EXTERIOR FIRE-X treated plywood shall not be used in roof designs employing a radiant shield that is located underneath the bottom surface of the sheathing.

NOTE: THESE SPAN RATINGS ARE BASED ON TEST RESULTS FOR EXTERIOR FIRE-X TREATED PLYWOOD AFTER EXTENDED EXPOSURE TO ELEVATED TEMPERATURES AND MOISTURE.

HOOVER
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A RYCEM COMPANY

11/96 http://www.HooverFRTW.com