CEL CONSULTING, INC
Product Evaluations - Metallurgy
Structural Investigations - Forensics

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Project Number 53004C
Report Number 16C308

Subject: Report of Wood Rod Hanger Testing

As requested tests were performed on the subject rod hangers. ICC Evaluation Service, LLC (ICC-ES) AC233, Section 4.0, TEST METHODS was used as a guideline for the testing. Only average ultimate loads were to be determined and reported. Determination of allowable loads is not included in the scope of work.

Scope

The following table provides the scope of the testing.

Wood Rod Hangers Test Base Material & Rod Size	Shank Diameter, in, & Test Quantities			
	Vertical Mount		Side Mount	
	1/4	3/8	1/4	3/8
Douglas Fir 1/4" rod	15	-	-	-
Douglas Fir 3/8" rod	15	15	15	15
Douglas Fir 1/2" rod	-	15	-	-

Test Specimens

Wood Rod Hangers were submitted to our laboratory for the testing.

Selected dimensions of rod hangers that were tested were measured and compared to the product dimension drawings provided by the supplier. Two or three specimens of each were measured and results averaged. The product drawings and results of the dimensional measurements are provided in Appendix 1. Dimensions measured were in compliance with the product dimension drawings

Mechanical and chemical tests were performed on the rod hangers representative of each shank size to verify these properties. The requirements were found on product inspection sheets provided by the supplier and were not listed on the dimension drawings provided. The raw material was determined to be AISI C1022 steel. The hardness requirements were core hardness 450 HV (Vickers Pyramid Number) maximum and surface hardness 680-750 HV. Hardness was found to be in substantial compliance with these values. Case thickness was not determined. The results of these tests are provided in Appendix 1.

Wood Base Material

Eight 8' lengths of Douglas Fir 2x4s Grade Standard and Better were purchased from Home Depot for the testing.

The 8' lengths were placed in our conditioning chamber at 65% ± 5% relative humidity and 68ºF ± 5ºF temperature as required. They were individually and uniquely marked and monitored for moisture content with a calibrated electronic Delmhorst moisture meter, Model J-1000, with the moisture reading settings for Douglas Fir.

Specific gravity was determined in accordance with Method A of ASTM D2395, *Standard Test Method for Specific Gravity of Wood and Wood-Based Materials*. Two full width specimens 1.5" in length were sawn from each 8' length at the third points and trimmed to 3" width and 1.5" height. The specimens were then placed in a vented drying oven at 103ºF ± 2ºF oven and reweighed until they reach a constant weight. The specific gravity is then calculated from the volume and the oven dried weight. The specific gravity results and an example calculation are provided in Appendix 3.

The moisture content of the wood was determined just prior to testing with the Delmhorst moisture meter. Moisture readings were all in the range of 14% to 15%. AC233 specifies a range of 11% to 14% for dry in-service conditions usage so this minor deviation would have negligible effect on the results and would be on the conservative.

The 8' lengths were cut into 4" (for bottom mount tension) and 11" (for side mount shear) test members after reaching equilibrium.

Since the actual specific gravity results were all less than or equal to 0.50, normalizing the test results to the minimum specific gravity of 0.50 for Douglas Fir specified in the National Design Specification for Wood Consttruction (NDS) was not applicable.

Testing Procedures

Testing was performed on a 20 Kip capacity Instron universal testing machine with elongation measured internally (calibration traceable to N.I.S.T.). The samples were tested utilizing fixtures in accordance with the intent of ASTM D1761 based on the configuration of the hangers for shear loading versus normal wood screws.

A 1/8" pilot hole was predrilled to at least the screw shank length for all installations. All rod hangers were installed to their full embedment depth based on contact with the rod hanger body to the test member surface. The 1-1/2" face of the 2x4s was used for all testing to address typical and worst case locations anticipated for rod hanger use.

For vertical mount tension tests the hanger was installed at the midpoint of the 4" length in the middle of the 1-1/2" face of the 2x4. The 2x4 with installed hanger was placed inside a steel test fixture with a 2ò diameter opening so that the fixture restrained the 2x4 during load application. The installed hanger was centered in the opening. The fixture was secured to the Instron base, and a high strength threaded pull rod was installed in the hanger and attached to the Instron. Load was applied at a rate of 0.100 in/min until failure.

For determination of side mount shear strength, the hangers were installed in the middle of the 1-1/2" face of the 11" long 2x4 with 2" end distance. Load was applied to one hanger using a special steel offset fixture. The hanger head was placed in a hole in an steel offset fixture that was slighty larger than the hanger head and secured to the fixture with a high strength threaded rod installed through a tapped hole in the fixture bottom and threaded into the tapped hole in the hanger side mount. Load is transferred by the fixture to the high strength threaded rod and to the hanger head which is also attached to the threaded rod. The offset steel fixture was needed to account for the eccentricity of the single hanger connection. The steel offset fixture was secured to the Instron head, and the 2x4 attached to a steel fixture secured the Instron bed. Load was applied at a rate of 0.100 in/min until failure.

See photographs in Appendix 4 for test set-ups and typical failure modes.

Res□□s

The following table provides summarized results. Load versus displacement graphs are provided in Appendix 3.

Rod Hanger Size	Screw Shank Size, inches	Mount Type	Average Ultimate Load, lbs. [1]	COV, %	Failure Mode
1/4"-20	1/4 x 2	Bottom	1673	10.4	Pullout
3/8"-16	1/4 x 2	Bottom	1676	12.2	Pullout
		Side	1411	12.2	Shank shear/wood splitting
3/8"-16	5/16 x 2-1/2	Bottom	1704	13.9	Pullout
		Side	1715	15.5	Shank shear/wood splitting
1/2"-13	5/16 x 2-1/2	Bottom	2202	12.5	Pullout

Use of Results

The data derived from these tests may be used for allowable stress design (ASD) provided an appropriate factor of safety is applied to the average ultimate loads.

Rod hangers may be installed in the 1-1/2" face of 2x lumber or in the wider face. Distance to the ends or edges must be a minimum of 2".

Results are applicable to dry in-service conditions only.

Conclusion

The testing program was conducted in substantial conformance with the requirements of AC233, Section 4.0, and referenced documents with modifications for shear testing to address how load is applied to the rod hangers versus normal wood screws.

References

1. ICC Evaluation Service, LLC, Brea, CA: AC233, *Acceptance Criteria for Alternative Dowel-Type Threaded Fasteners, June 2012*
2. ASTM International, West Conshohocken, Pennsylvania: ASTM D1761-12, *Test Method for Mechanical Fasteners in Wood;* ASTM D2395-14, *Standard Test Method for Specific Gravity of Wood and Wood-Based Materials*
3. American Forest & Paper Association, Washington D.C.: ANSI/AF&PA *National Design Specification for Wood*

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Appendix 1 – Test Specimens
Appendix 2 – Load-Displacement Graphs
Appendix 3 - Wood Base Materials
Appendix 4 – Photographs