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"Safety Boot™" Temporary Railing Base Test

Report Number: 08010055
(6 Pages & 16 Figures)

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1.0 INTRODUCTION

At request of Safety First Systems Inc., Infinity Testing Solutions (ITS) conducted a series of structural tests on "Safety Boot™" temporary railing base product in accordance with Ontario Regulation 213/91, section 26.

Eighteen (18) "Safety Boot" samples with specified installation fasteners were received on April 8, 2008. Four (4) additional samples were received on April 17, 2008.

A total of 17 tests were performed and described in this report. The first three (3) tests were performed on a complete guardrail system constructed using "Safety Boot™" base following the Installation Instruction provided by the client. Eleven (11) tests were performed on single posts using "Safety Boot™" base installed on three (3) types of floor materials/structures as described in the Installation Instruction. Three (3) cold temperature tests were also conducted in order to evaluate the product performance in cold winter condition.

All engineering units in the report are Imperial units unless specified.

2.0 TEST PROCEDURE

2.1 Test apparatus and loading procedure

A 14" stroke servo-hydraulic actuator was utilized to apply the required load. The applied load was measured with a 5000 lb load cell installed on the end of the actuator rod. The load was applied on the railing or post using a loop of wire rope. For proof load tests, the load was automatically increased from zero to the specified level in 30 second at a constant ramp rate. The test load was held for 60 seconds and then decreased to zero. If the structure was able to maintain the test load for 60 seconds, the test is considered pass the requirement. For single post tests, ultimate strength test was performed after each proof load test. The test load was increased until no higher load could be achieved (test to failure). The maximum load was recorded when test stopped.

2.2 Guardrail system test

A portion of a guardrail system consists of two vertical posts, a 2x4 top rail, a 2x4 intermediate rail and a 2x4 toe board was constructed according to Installation Instruction. The two vertical posts were placed at the maximum allowable 8 feet centre to centre as the "worth case". The guardrail system was installed on a 23/32 plywood floor, since this is the most common sub-floor material in construction. Four (4) 3/8 x 3" lag screws with 1-1/2" fender washers were used to install the "Safety Boot™" base onto the floor surface. The lag bolts were fastened into the 23/32 plywood and solid 2x10 lumber blockings underneath the floor as instructed. The plywood floor was rigidly supported on an 8' x 15' T-slotted steel plate as a reaction base. 2x4 beams were placed between the steel base and the floor blocking as spacers to raise the 2x10 blocking 1-1/2" above the steel surface. All solid lumber material used for testing was Spruce.

A photograph of the guardrail installation can be seen in Figure 1.

Three (3) tests were conducted on the guardrail as described below:

Test # 1: Horizontal load test on the top rail at mid-point as shown in Figure 2.

Two (2) proof load tests were performed in this configuration, 152 lb. and 200 lb. in accordance with Ontario and Federal Regulations. The load carrying capacity of the post/base combination was tested separately on single post described later in this report.

Test # 2: Horizontal load test on toe board as shown in Figure 3.

A proof load of 51 lb. was applied at the mid-point of the toe board, in order to evaluate the mid-point strength. The proof load was then increased to 102 lb at the same location. In this case, each end of the toe board was subjected to 51 lb. of force at the same time proving that the toe board was able to withstand 51 lb. horizontal load at any location.

Test # 3: Vertical load test on top rail at mid-point as shown in Figure 4.

A downward proof load of 101 lb. was applied at the mid-point of the top rail, in order to evaluate the mid-point strength on vertical load. The downward load was then increased to 202 lb. at the same location, in order to distribute two equal 101 lb. at each end of the top rail. Each post was supporting 101 lb of vertical load in this case, proofing that the top rail was able to withstand 101 lb. vertical load at any location.

Since the intermediate rail was constructed using the same material as the top rail and installed only half the height as the top rail on the posts, the load test on intermediate rail became not necessary if the top rail horizontal and vertical load tests were passed.

2.3 Single post test

Single post tests were performed to evaluate the anchoring strength of the "Safety Boot™" base on different types of sub-floor materials. A horizontal load was applied at 43 inches above the floor toward the unprotected side of the floor structure. The test setup and a sample at failure pictures are presented in Figures 5 and 6.

Test # 4 to 6: Single post horizontal load test on solid 2x10 sub-floor material.

Four (4) 3/8 x 2 lag screws with 1-1/2 washers were used to fasten the "Safety Boot™" bases on the 2x10 beam's flat surface (Figure 7). A 152 lb. proof load test followed by ultimate strength test was performed on each sample.

Test # 7 to 9: Single post horizontal load test on 23/32 plywood with 2x10 blocking.

Four (4) 3/8 x 3 lag screws with 1-1/2 washers were used to fasten the "Safety Boot™" bases through the 23/32 plywood and the 2x10 beam (Figure 8). A 152 lb. proof load test followed by ultimate strength test was performed on each sample.

Test# 10 to 12: Single post cold temperature test on 23/32 plywood with 2x10 blocking.

Four (4) 3/8 x 3 lag screws with 1-1/2 washers were used to fasten the "Safety Boot™" bases through the 23/32 plywood and the 2x10 beam (Figure 9). The sample was then pre-conditioned in a small chamber at specified temperature on the installation for 60 to 90 minutes before the test performed. Part of the floor top surface and the lower portion of the post were also subjected to the test temperature (Figures 10 and 11).

The following temperatures were applied:

Test #10 @ -20 °C for 60 minutes prior to test
Test #11 @ -30 °C for 80 minutes prior to test
Test #12 @ -35 °C for 90 minutes prior to test

A 152 lb. proof load test followed by ultimate strength test was performed on each sample.

Test # 14 to 15: Additional single post horizontal load test on solid 2x10 sub-floor material.

These two additional tests were performed with the base installed on a batch of separately purchased 2x10 beams in order to understand the property variation between the solid wood materials.

Test # 16 to 18: Single post horizontal load test on 1-1/8 Surd-I-Floor plywood.

Since the 1-1/8 Surd-I-Floor plywood was not available in Canada, a 6/17 plywood board and a 23/32 plywood board were stacked together to make up a 1-1/8 thickness, as agreed by the client. The boards were fastened together with deck screws to simulate a single piece material. Five (5) 3/8 x 2 lag screws with 1-1/2 washers were used to fasten the "Safety Boot™" bases on the floor material (Figures 12). A 152 lb. proof load test followed by ultimate strength test was performed on each sample.

3.0 RESULTS

The guardrail system with "Safety Boot™" bases passed all proof load tests without showing any failures. The summary of the guardrail system test is listed in Table 1 below:

Table 1: Summary of Guardrail System Test

Test No	Temp.	Test load case	Sub-floor	Fastener	No of Fasteners	Proof load	Result
1	Room	Horizontal on top rail mid-point	23/32 plywood with 2x10	3/8 x 2	4	152 lb. 200 lb.	Pass Pass
2		Horizontal on toe board mid-point				51 lb. 102 lb.	Pass Pass
3		Vertical on top rail mid-point				101 lb. 202 lb.	Pass Pass

The summary of single post test results is listed in Table 2 below. All tests passed proof load testing without showing any failures. For 2x10 solid floor or 1-1/8 plywood floor installations, the lag screws were pulled out from the sub-floor materials at ultimate load. For the typical 23/32 plywood with 2x10 under blocking, the "Safety Boot" samples were permanently deformed under the ultimate load. Crack development was also observed on the base top portion when the base deformed. Based on the failure mode, the "Safety Boot™" base itself has an average ultimate strength of 645 lb. when a horizontal load applied at 43 inches above the floor on the post.

Table 2: Summary of Single Post Test

Test No	Temp.	Subfloor	Fastener	No of Fasteners	Proof load	Result	Max. load	Failure mode
4	Room	2 x 10 Spruce	3/8 x 2	4	152 lb.	Pass	250	Lag screws were pulled out
5						Pass	315	Lag screws were pulled out
6						Pass	226	Lag screws were pulled out
7	Room	23/32 plywood with 2x10	3/8 x 2	4	152 lb.	Pass	651	Base deformed
8						Pass	641	Base deformed
9						Pass	644	Base deformed
10	-20 °C	23/32 plywood with 2x10	3/8 x 2	4	152 lb.	Pass	832	Lag screws were pulled out
11	-30 °C					Pass	737	Base broke
12	-35 °C					Pass	744	Lag screws were pulled out
14	Room	2 x 10 Spruce	3/8 x 2	4	152 lb.	Pass	439	Lag screws were pulled out
15						Pass	466	Lag screws were pulled out
16	Room	1-1/8 plywood	3/8 x 2	5	152 lb.	Pass	337	Lag screws were pulled out
17						Pass	366	Floor fractured
18						Pass	358	Lag screws were pulled out

Note: Test #13 (for R&D purpose only) was not performed on any of the above floor materials, and the result is not covered in this report.

Figures 13 to 16 demonstrate four (4) different types of failures from the tests.

4.0 CONCLUSIONS

With proper installation following Installation Instruction provided by Safety First System Inc., the guardrail system using "Safety Boot™" temporary railing base has met the requirements of Ontario Regulation 213/91, section 26.

Based on test data, the analysis results of the "Safety Boot™" base side-load resistance capacities on different floor materials and temperatures are calculated and listed in Table 3 as following:

Table 3: "Safety Boot™" Average Strength

Temperature	Sub-floor	No of Fasteners	Average failure load
Room	2 x 10 Spruce	4	339 lb.
Room	23/32 Plywood with 2x10 Spruce	4	645 lb.
Room	1-1/8 Plywood	5	354 lb.
-20 °C	23/32 Plywood with 2x10 Spruce	4	832 lb.
-30 °C	23/32 Plywood with 2x10 Spruce	4	737 lb.
-35 °C	23/32 Plywood with 2x10 Spruce	4	744 lb.

The side-load resistance capacities of the guardrail posts using "Safety Boot™" temporary railing base exceed the requirement of Ontario Regulation 213/91, section 26, when tested on three types of specified sub-floor materials.

Reported by:

David Wang, P.Eng.

This report refers only to the particular samples provided, and is limited by the test and/or analysis performed. Similar articles may not be of like quality, and other testing and/or analysis methods might give different results.

Figures

(8 Pages)

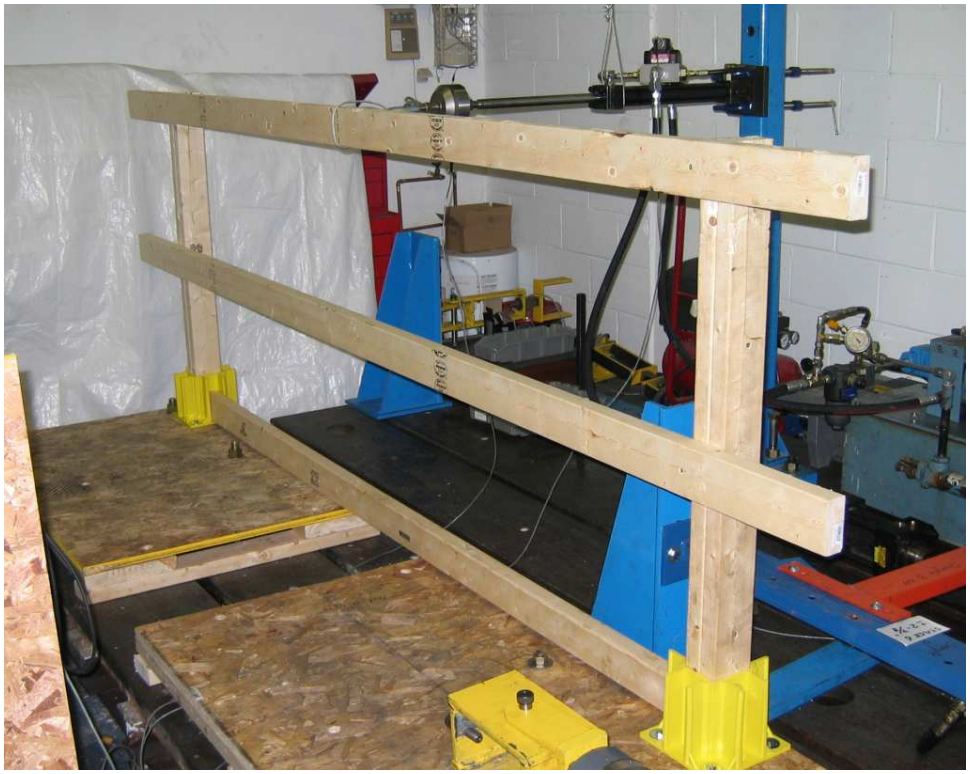

Figure 1: Guardrail system installation

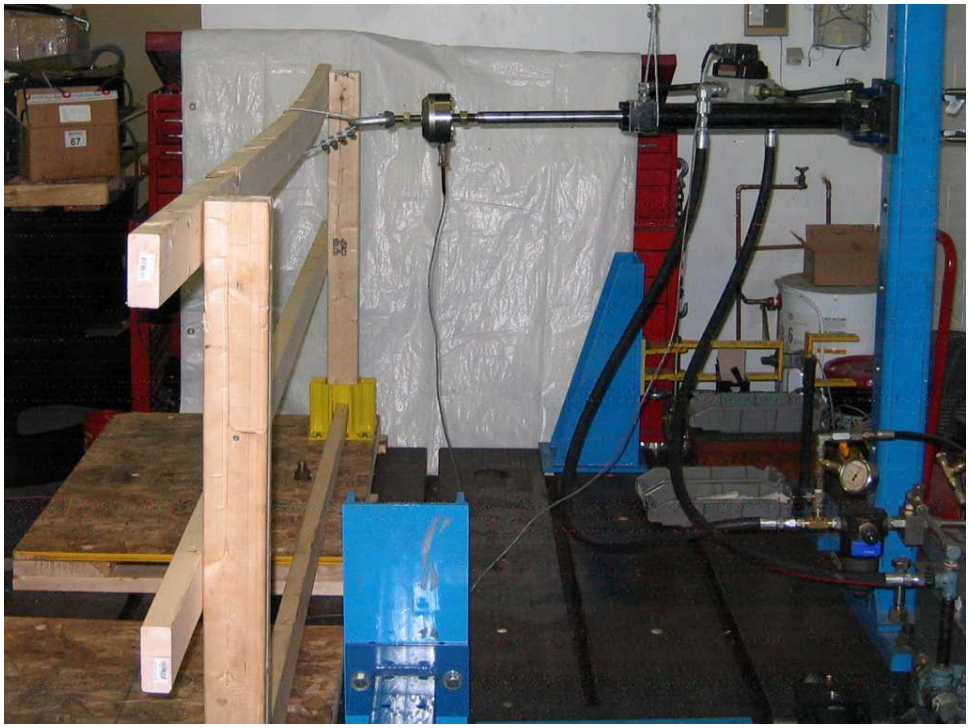

Figure 2: Top rail horizontal load test

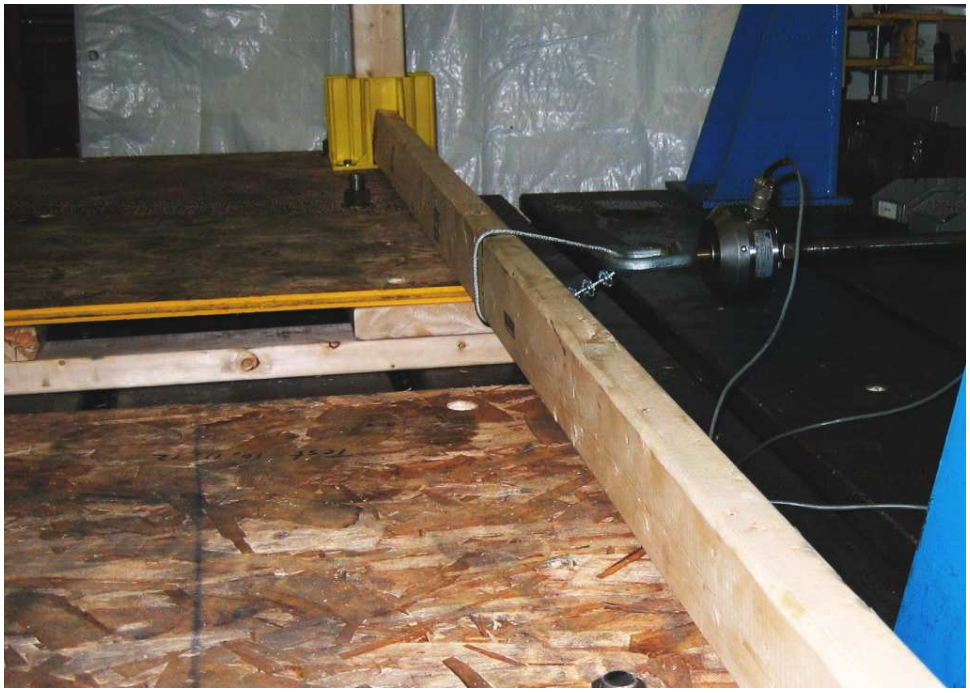

Figure 3: Toe board horizontal load test

Figure 4: Top rail vertical load test

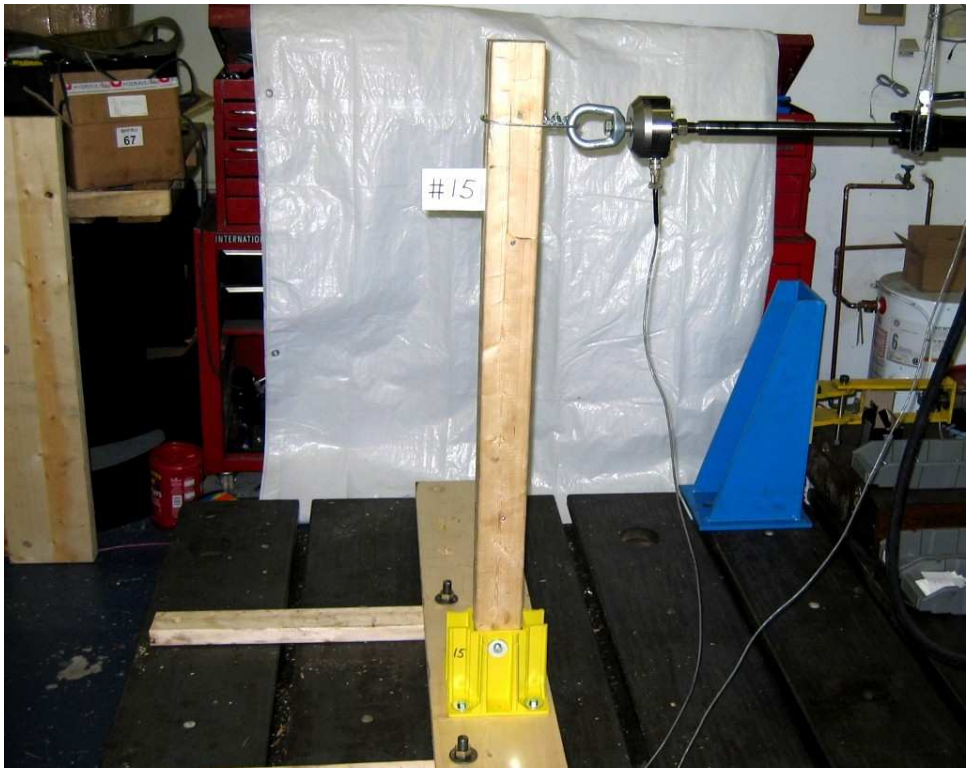

Figure 5: Single post test setup

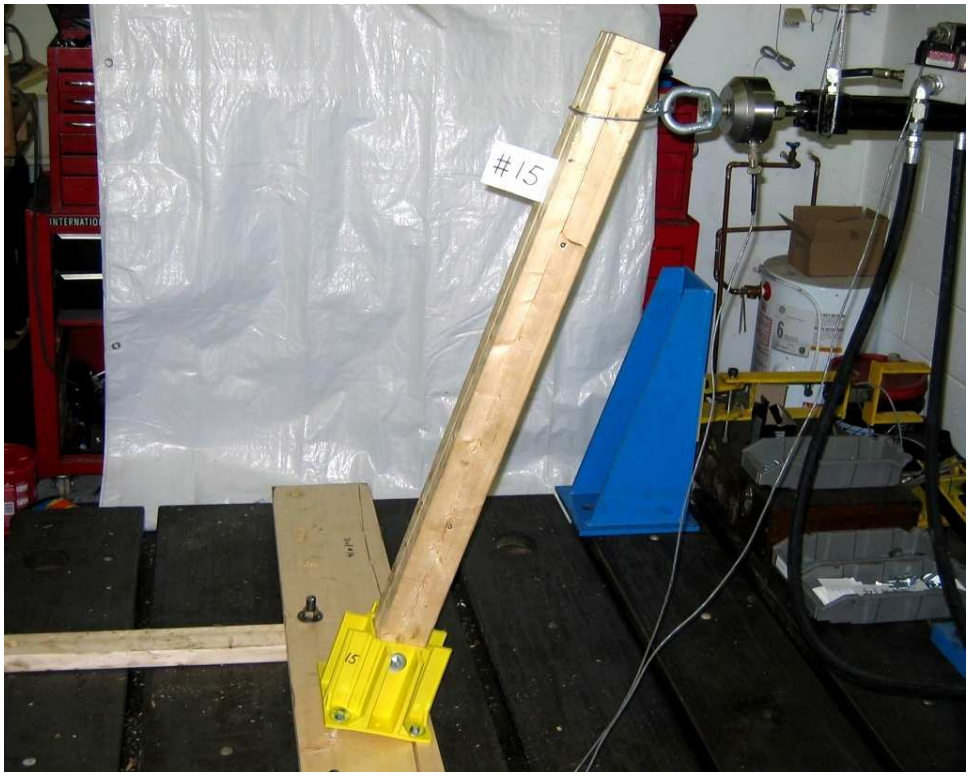

Figure 6: Single post test at failure

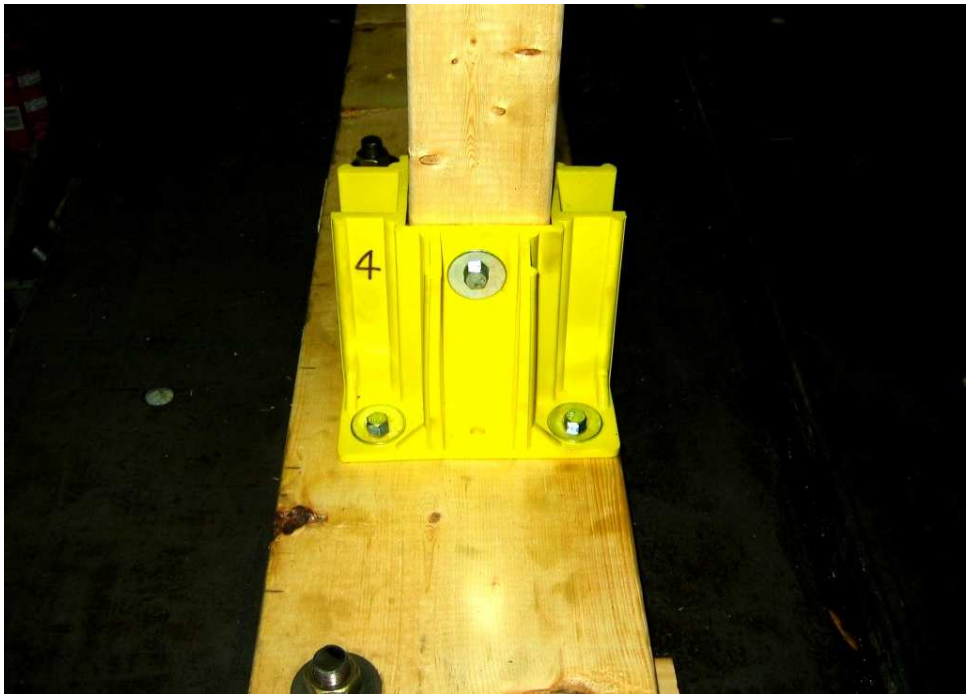

Figure 7: 2x10 sub-floor installation

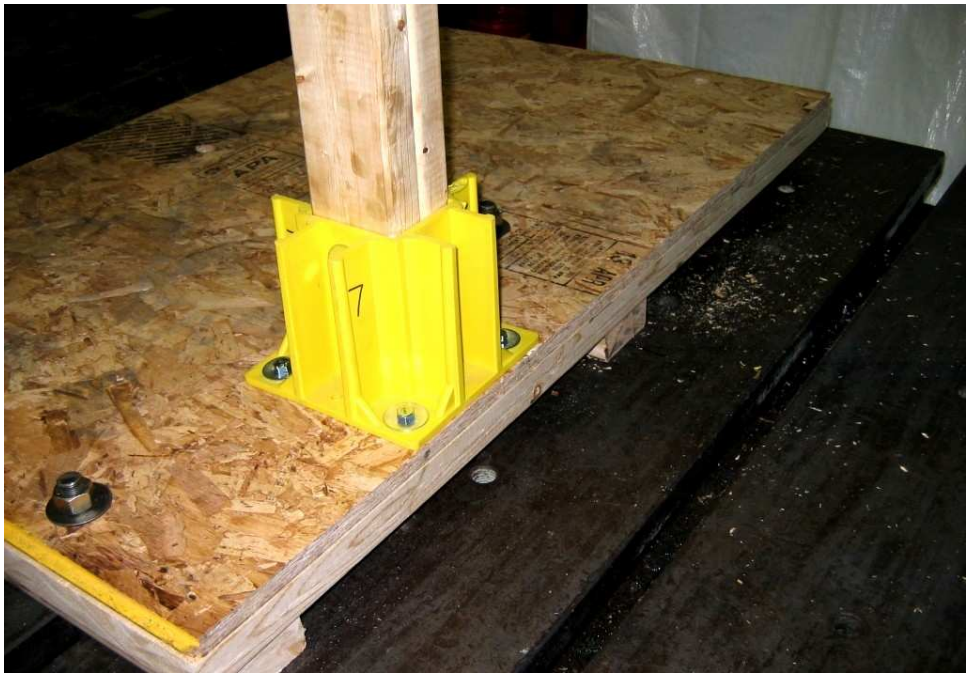

Figure 8: 23/32 plywood sub-floor installation

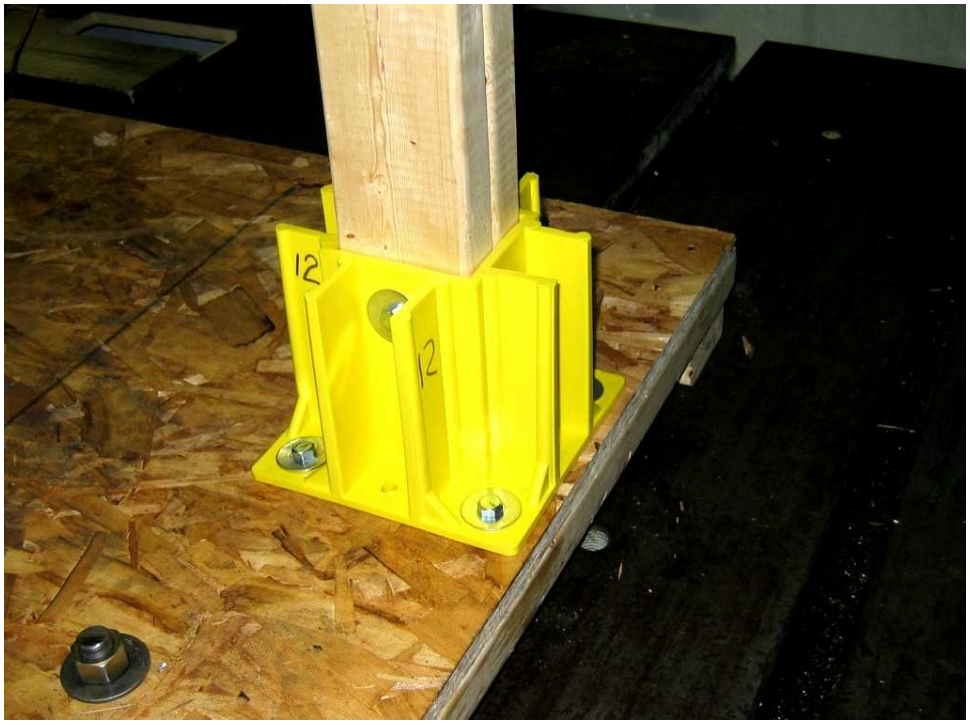

Figure 9: 23/32 plywood sub-floor installation for cold temperature test

Figure 10: Cold temperature test setup

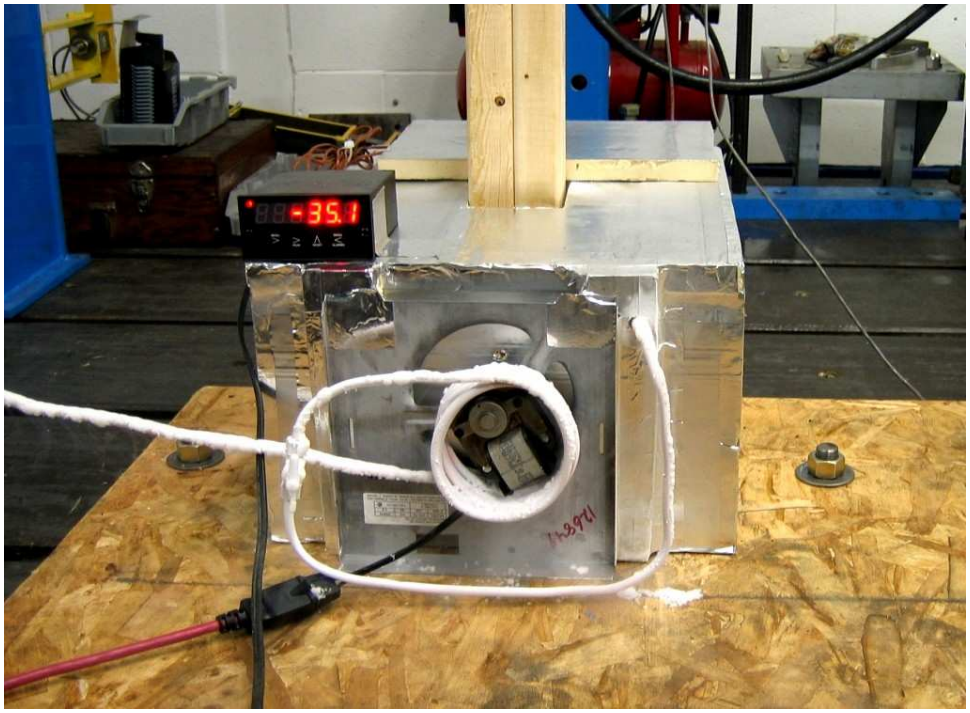

Figure 11: Cold temperature test chamber

Figure 12: 1-1/8 plywood sub-floor installation

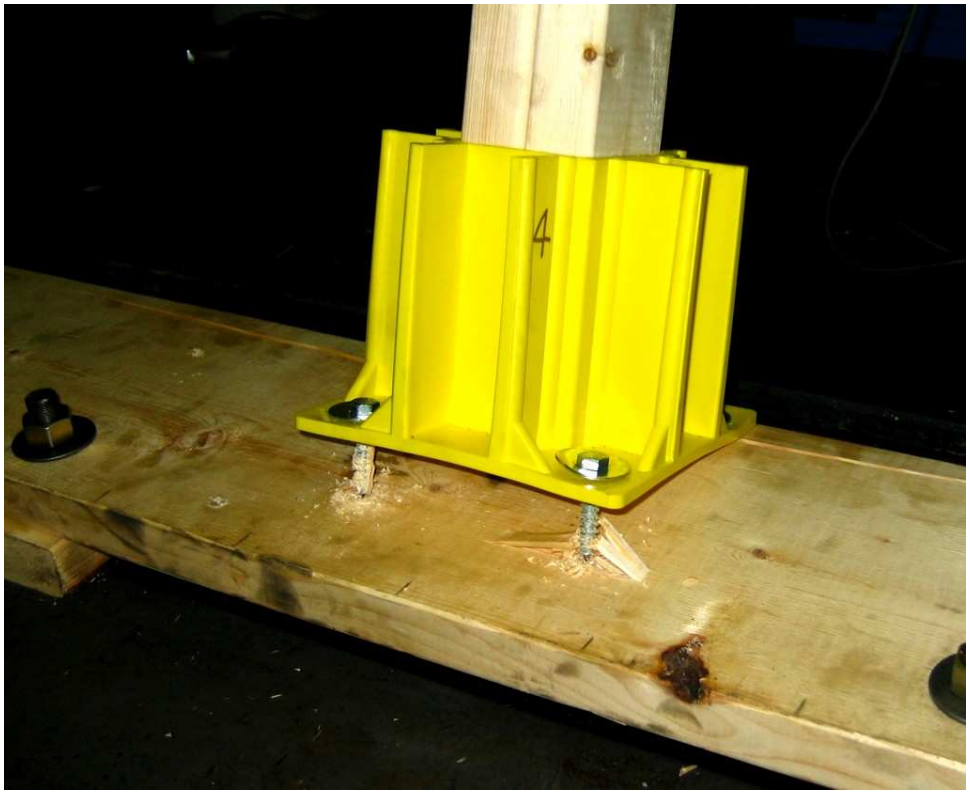

Figure 13: Lag screws pulled out failure in Test #4

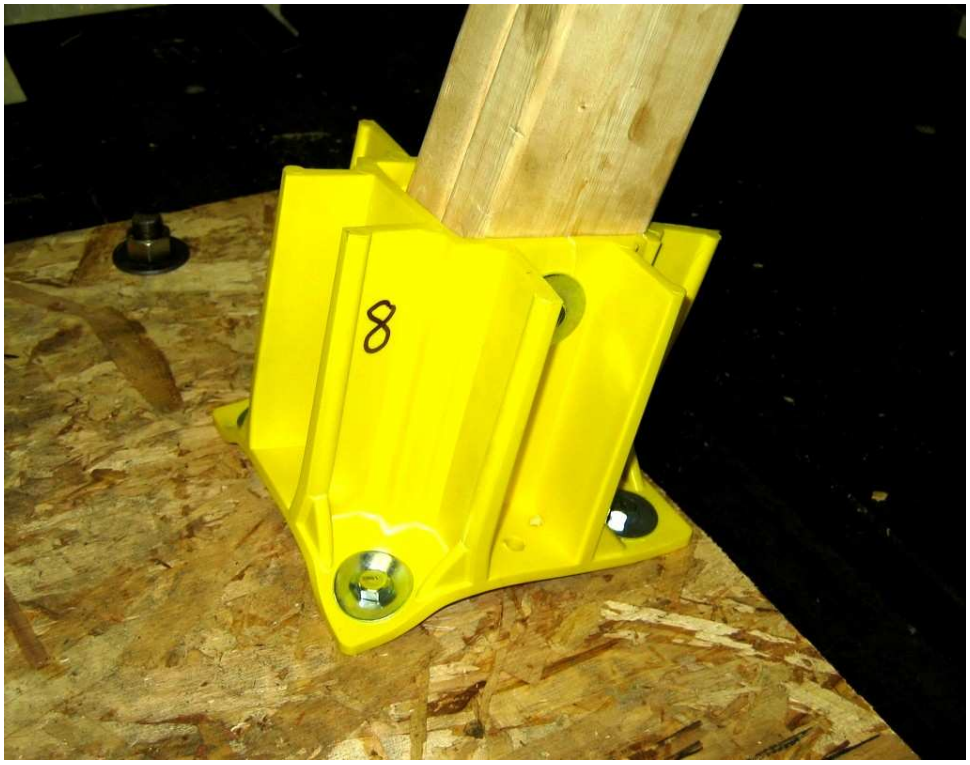

Figure 14: Base deform and crack failures in Test #8

Figure 16: 1-1/8 plywood sub-floor fractured in Test #17