Paper No. 99-4206
An ASAE Meeting Presentation

EVALUATION OF SPORTS SURFACE SYSTEM STRENGTH: A COMPARISON OF ENGINEERED FLOORING STRIP AND TRADITIONAL TONGUE-AND-GROOVE RANDOM LENGTH FLOORING STRIPS

By:

Paul W.Elliott, Ph.D.
Research Engineer
The Robbins Institute
Robbins Sports Surfaces
Cincinnati, OH 45226

Dr. Gary W. Krutz
Professor
Ag. and Bio. Engineering Dept.
Purdue University
West Lafayette, IN 47907

Michael Hodge
Service Engineer
Cummins Engine Co.
Columbus, IN 47202

Ben Lovett
Design Engineer
Caterpiller Ag. Products Inc.
Dekalb, IL 60115-9590

Summary:
This study examined the strength of sports surface systems constructed from engineered and traditional solid wood flooring strips. The study found that engineered seams could increase system strength by up to 180%, and that engineered joints increased system strength up to 62%. This study also found that 25/32” (21 mm) thick engineered flooring strips could produce systems which were up to 145% stronger than 33/32” (26 mm) thick traditional flooring. The study found evidence to support the idea that the tongue-and-groove geometry is a primary key in increased system strength.

Keywords:

Strip Flooring, Sports Surface, Basketball, Strength, Engineered Flooring

The author(s) is solely responsible for the content of this technical presentation. The technical presentation does not necessarily reflect the official position of ASAE, and its printing and distribution does not constitute an endorsement of views which may be expressed.

Technical presentations are not subject to the formal peer review process by ASAE editorial committees; therefore, they are not to be presented as refereed publications.

Quotation from this work should state that it is from a presentation made by (name of author) at the (listed) ASAE meeting.

EXAMPLE — From Author’s Last Name, Initials. “Title of Presentation.” Presented at the Date and Title of meeting, Paper No X. ASAE, 2950 Niles Road, St. Joseph, MI 49085-9659 USA.

For information about securing permission to reprint or reproduce a technical presentation, please address inquiries to ASAE.

ASAE, 2950 Niles Rd., St. Joseph, MI 49085-9659 USA

Voice: 616.429.0300 FAX: 616.429.3852 E-Mail:<hq@asae.org>

1. INTRODUCTION

Research conducted through the Purdue Research Foundation compared traditional random-length maple strip flooring to Robbins Continuous Strip XL™ maple strip flooring. Sports surface strip flooring has experienced little change in North America for the last 50 to 75 years. The industry is still dominated by solid wood products. The newest modification to traditional tongue-and-groove strip flooring that was found was an updated definition to the profile[1]. This modification was adopted by the Maple Flooring Manufacturer's Association (MFMA) in 1959.The MFMA currently has only adopted grading and production for solid wood, tongue-and-groove, random length strip flooring. It has not developed standards for any engineered wood playing surfaces.

In the early 1990's, Robbins Inc. started development of Continuous Strip XL, an engineered tongue-and-groove flooring strip that is fundamentally similar to the flooring governed by the MFMA. This engineered flooring strip has a traditional style tongue-and-groove end-match, and side-match. The flooring strips in the traditional flooring range from 12 - 96" (304 - 2400 mm) in length. The engineered flooring strips range from 72 - 84" (1800 - 2100 mm) in length. The increase in strip length and the uniformity of strip length was achieved by joining individual segments to make a single flooring strip. For the purpose of clarity these internal joints will be referred to as engineered seams. The phrase 'end-joint' will denote a traditional tongue-and-groove end-match joint. By joining several short pieces with engineered seams, as many as 75% of the end-joints can be eliminated from the flooring surface.

The engineered seam is achieved through both machining and through gluing. Installation of flooring strips requires that end-joints be produced with a relatively large tolerance. This ensures that the strips will easily slide together, making the flooring easier to install. Because the engineered seams are not assembled at the job-site they are produced to much small tolerances.

This study examined the strength of sports surface systems constructed of the traditional and the engineered products. It was thought that the combination of the reduction of end-joints, the improved machining tolerances, and the introduction of glue in the engineered seams would produce noticeable strength differences. Several system constructions were examined.

2. DEFINITIONS AND DESCRIPTIONS

This section provides the definitions of common strip flooring terminology included in this paper. It also provides definitions of some terms that are used to simplify later discussions.

Side-Match: This refers to the joints that run the entire length of the flooring strip. They are found on the (long) sides of both flooring strips examined in this study.

End-Match: This refers to the joints on the ends of the individual flooring strips.

Tongue-and-Groove: This refers to a joint where flooring strips are produced with a tongue on one side (end), and a groove on the other side (end).A schematic of this type of joint can be found In Figure 1(a).

Traditional Joint: This refers to an end-joint constructed similar to Figure 1 (a), where each flooring strip is one segment of wood.

Engineered Seam: This refers to the machined and glued joints that are present in the engineered strips that were examined in this study. A schematic of these seams can be found in Figure 1 (b).

Engineered Joint: This refers to an end-joint constructed similar to Figure 1 (c) where each flooring strip can be comprised of multiple segments, and engineered seams are allowed to be within 6" of the end-match.

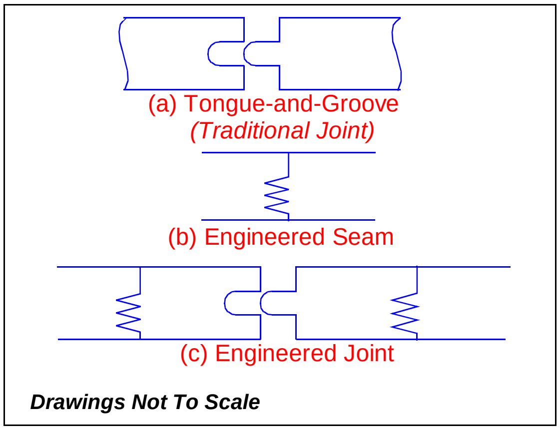

Figure 1: Joint Schematics

3. METHODS

This study used 2-1/4” (57mm) wide flooring strips to examine the strength of systems constructed from traditional and engineered flooring strips. The samples were tested using a Sintech® compression-tensile testing machine. A steel block of area 2.25 in^2 (1450 mm^2) was used to load the samples. The block applied pressure to the floor system over an area that closely represents the area loaded by wheels commonly found on rolling bleachers. The deflection and loading produced at the first sign of failure were obtained from the 'force deflection time history curves'. A schematic of the test set-up is shown in Figure 2.

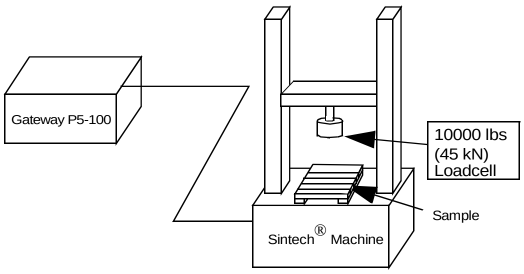

Figure 2: Schematic of materials test setup.

All samples were constructed using similar materials and techniques where appropriate. All samples were five boards or 11.25” (289 mm) and 18” (457 mm) long, unless otherwise noted. The following sections outline the samples which were included in this study. Figures have been provided to illustrate joint locations. Figures are not drawn to scale, unless noted as such.

3.1: Comparison of 25/32” Traditional and Engineered Material

This study examined the strength of floor system samples constructed of the various materials. All samples included in this section were constructed of 25/32” (20 mm) thick strip flooring 1” (25 mm) thick by 2.5” (64 mm) wide sleepers, 16” (406 mm) on-center, with a 15/32” (12 mm) thick plywood subfloor. The three main sample types examined included: traditional joints, engineered joints and engineered seams. Samples were constructed with the following joint locations:

a) One joint: Samples had either an end-joint or engineered seam, in identical locations respectfully, in the center of the board, directly under the applied point load. (See Figure 3.)

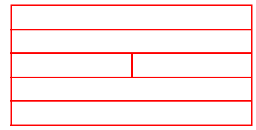

Figure 3: Top view of samples containing one end-joint or seam.

b) Two joints: Samples were constructed with two of the center boards each containing a single joint either end-joint or engineered seam. These joints were offset by 10", to simulate installation in a larger floor. (See Figure 4.)

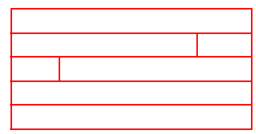

Figure 4: Top view of samples containing two end-joints or seams.

3.2: Comparison of 33/32” and 25/32” Flooring Strips

System samples were constructed in the same manner as in section 3.1 which evaluated 25/32” (21 mm) thick flooring strips. Samples were constructed of the 33/32” (26 mm) and 25/32” (21 mm) traditional flooring strips, and samples constructed of 33/32” and 25/32” thick engineered flooring strips. Samples were constructed by nailing flooring strips to 2.5” (72 mm) wide by 1” (25 mm) thick sleepers. These sleepers were placed 16” on center.

Samples were created with 1 traditional joint, 1 engineered seam, 2 traditional joints, and 2 engineered seams. See Figure 3 and 4 for joint locations.

3.3: Break Force Determination

The break force data was used to generate force versus deflection curves similar to the one shown in Figure 5. Figure 5 shows data from a test that was performed well beyond failure. Break force was determined by listening for loud cracks. Upon hearing cracking of the boards, testing was concluded. Often these cracks were accompanied by a dramatic change in the slope of the force deflection curve, this is evident in Figure 5.

All results shown were obtained from testing and analyzing two samples. The allotted time did not allow larger sample sizes.

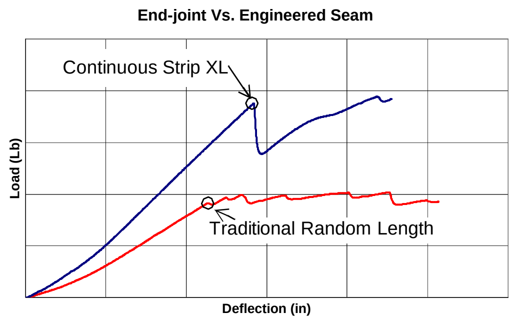

Figure 5: Typical Force Deflection Curve.

4. RESULTS

4.1: Comparison of 25/32" Traditional and Engineered Material

This section contains the comparisons of 25/32" thick traditional and engineered flooring strips. Table 1 contains the break force and the deflection at breakage for the samples described in section 3.1.

Table 1: Break Data For 25/32" Strip Flooring, with 15/32" subfloor, and 2.5" wide Sleepers 16" OC

Product	# Joints / seams	Defl. (in)	Force (lb)
Traditional	1 Joint	0.107	589
Engineered	1 Joint	0.163	957
Engineered	1 Seam	0.210	1674
Traditional	2 Joints	0.205	1606
Engineered	2 Joints	0.239	1915
Engineered	2 Seams	.230	2032

As expected, the data in Table 1 shows that the engineered seam is significantly stronger than traditional joints. Where the point-load was applied above a single joint, the engineered seam was found to be 184% stronger than the traditional joint (See Figure 6). A strength increase of 27%, or more than 400 lbs (1700 N), was realized when two engineered seams replaced two traditional joints. In both of the above cases, the increase of supported load was accompanied by an increase in the deflection when the sample broke.

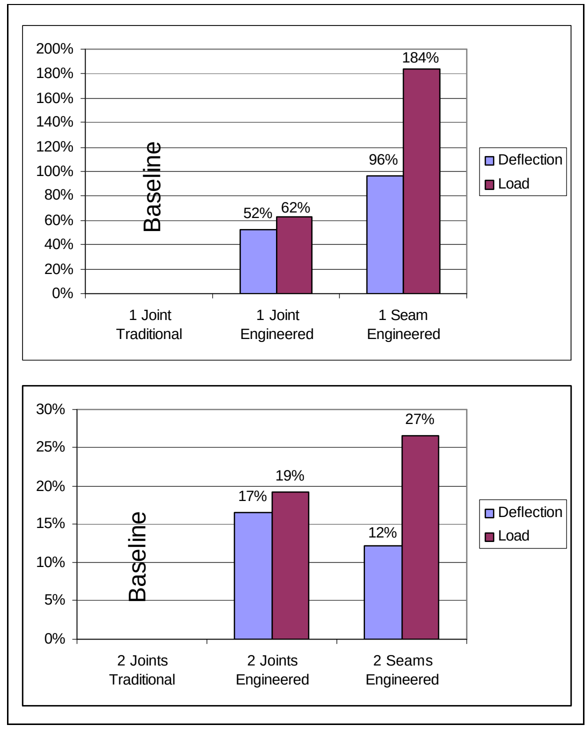

Figure 6: Percent Increases Provided By 25/32" Engineered Strip Flooring Over 25/32" Traditional Strip Flooring.

Something that was not expected was the increase in strength when the traditional joint was replaced by the engineered joint. It was suspected that the presence of the engineered seam near the end-match might weaken the system, compared to the traditional joint, but this was not found to be the case. In fact in samples with only one joint, the engineered joint supported 62% higher loads than the traditional joint. The engineered joint supported 19% higher loaded than the traditional joint when two joints were present. Again, these loading increases were supported with increases in deflection allowed prior to failure.

4.2: Comparison of 33/32" and 25/32" Flooring Strips

Table 2 contains the deflections and loads at which failure occurred.

Table 2: Break Data For Strip Flooring, and 2.5" wide Sleepers 16" OC

Product	# Joints / seams	Defl. (in)	Force (lb)
25/32" (21 mm) Traditional	1 Joint	0.238	883
33/32" (26 mm) Traditional	1 Joint	0.099	651
25/32" (21mm) Engineered	1 Seam	0.250	1593
33/32" (21mm) Engineered	1 Seam	0.259	2040
25/32" (21 mm) Traditional	2 Joints	0.205	856
33/32" (26 mm) Traditional	2 Joints	0.161	1752
25/32" (21mm) Engineered	2 Seams	0.301	1964
33/32" (21mm) Engineered	2 Seams	0.176	2264

The assumption that thicker flooring strips would not result in stronger flooring systems received some support in the results. The samples that were constructed with only one joint were the weakest of all samples tested. The joint was directly beneath the applied load and at the midpoint between the two sleepers.

The thicker traditional flooring strip actually failed before the thinner traditional flooring strip in the single joint construction. Both thicknesses of engineered strip withstood significantly higher loads than the 33/32" traditional flooring strip in a single joint configuration. Figure 7 shows that the seams in the 33/32" engineered flooring strips were significantly stronger (up to 213%) than the 33/32" traditional joints. Figure 7 also shows that the strength of systems constructed from 25/32" engineered flooring strips are as strong as, or stronger (up to 145% stronger) than systems constructed of the traditional flooring strips.

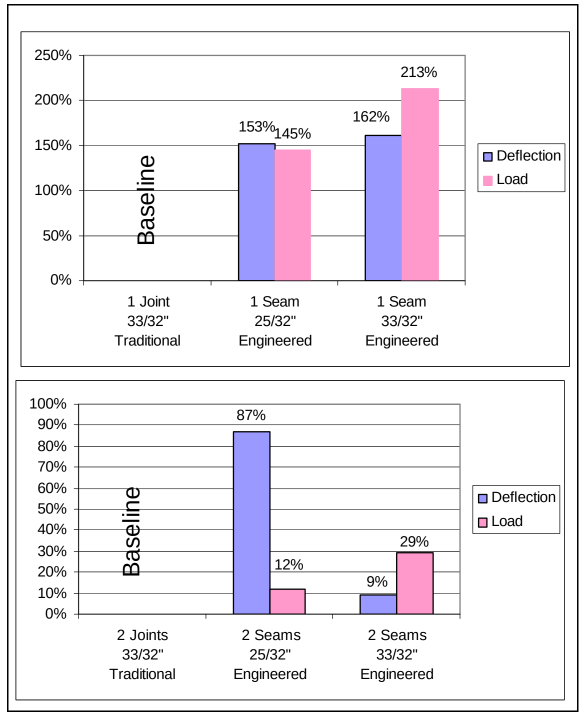

Figure 7: Percent Increases Provided By Engineered Seams in 25/32" and 33/32" Engineered flooring strips over 33/32" traditional joints.

5. CONCLUSIONS

Engineered seams in 25/32" strip flooring were found to produce sports surface systems up to 180% stronger than systems constructed of 25/32" traditional flooring strips. This increase was present even when the system included a 15/32" thick plywood subfloor.

Engineered joints were found to produce sports systems which were measurably stronger (up to 62% stronger) than systems constructed of traditional joints of the same thickness.

The break data for 33/32" and 25/32" thick traditional flooring strips tends to support the notion that the tongue-and-groove geometry is one of the primary keys that influence sports surface strength. Engineered seams in 33/32" thick engineered flooring strips were found up to 200% stronger than traditional joints in 33/32" flooring strips. Engineered seams in 25/32" thick flooring strips were also found to be up to 60% stronger than 33/32" traditional joints. This strength increase means that the maple flooring industry's conservation efforts [2] can be achieved without sacrificing system strength.

6. ONGOING STUDIES

The characteristics of the production processes of the two products were examined. It was found that the engineered strips were straighter than the traditional strips.It was also found that the machining tolerances on the engineered strips were superior to the tolerances of the traditional strips. The two production processes are also completely different. While all of these differences were noted, the causes of this increase in strength could not be isolated.

The Robbins Institute is currently exploring the effect of crooked, or bowed flooring boards on the sports surface strength. Finite element modeling of tongue-and-groove side-match joints has been performed simulating small bends, twists, or machining defects. This modeling already indicates that significant stresses are developed when these boards are installed. These stresses can not contribute to the strength of the sports surface system, and thus may result in a weakened system.

7. REFERENCES

[1] Maple Flooring Manufacturers Association (MFMA), *Revised Maple Flooring Standards for Strip Tongue-and-Groove End-matched flooring*, 1959.

[2] Maple Flooring Manufacturers Association, *'An Open Letter to the Members of The American Institute of Architects and the Construction Specificatons Institute'*, 1998.