



FEASIBILITY OF USING METAL PLATE CONNECTED TIMBERSTRAND LSL JOINTS IN THE TRUSS FABRICATION INDUSTRY

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ABSTRACT

Metal plate connectors enhance the load transfer by increasing the bearing area between wood member and the fastener. Because of having many advantages, metal plate connected (MPC) wood trusses have been widely used for over 50 years in many building applications especially in prefabricated homes. In this study, the possibility of using Timberstrand® laminated strand lumber (LSL) as a raw material was investigated. The behavior and the performance of metal plate connected Timberstrand connections loaded perpendicular to the grain in tension and shear at 0o, 45o and 90o orientations has been examined in accordance with ANSI TPI 1995 standards. According to the test results, Timberstrand joints performed better than solid southern pine joints in both tension (51%) and shear (10%) loading. This means that Timberstrand LSL has a very good potential for use in the truss fabrication industry.

Keywords: Metal plate connectors, Timberstrand, LSL joint

1. INTRODUCTION

The metal-plate-connected wood truss industry in the U.S. and Canada numbers approximately 1450 truss manufacturers (Hoover, 1996). It is estimated that this industry employs 35,000 people and utilizes 3 billion board feet of softwood, 120,000 tons of steel. The industry generates total revenue of two billion dollars. Today the world faces a very serious shortage of high quality wood for construction, and new ideas and products are needed to supply this high demand industry (Hoover, 1996). McAlister and Faust (1992) explained that the development of nontraditional uses for hardwoods, and especially soft hardwood species, which are currently underutilized, such as yellow poplar, sweet gum, and red maple, could have great economic advantages to landowners and to the lumber industry. In construction, increased use of hardwoods could provide markets for mature trees, reduce the pressure on softwood resource and provide an option for increased silvicultural diversity.

Timberstrand LSL was introduced and developed by Truss Joist Macmillan Co., Boise, Idaho. It can be used in residential and commercial construction as an alternative material to solid lumber. Timberstrand LSL is made from small-diameter aspen and yellow poplar timber instead of larger, more traditional lumber resources like Douglas-fir and southern pine. The manufacturing process converts as much as 76 percent of each log into Timberstrand LSL, nearly twice the conversion rate of traditional saw milling practices. (Truss Joist Macmillan, 1999). Timberstrand offers these benefits are resistance to shrinking, twisting and splitting, exceptionally long lengths-up to 48 feet, lightweight wood walls which minimize expensive wall-to-roof seismic connections, equivalent fire resistance rating to solid-sawn lumber thereby is allowing standard wood fire assemblies, thermal resistance of wood provides excellent insulation properties, custom precision end cuts and cut-to-length blocking is also available (Truss Joist Macmillan, 1999).

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Hoover (1996) reported that southern pine, Douglas fir, larch, hem-fir and spruce are used for manufacturing trusses. McAlister and Faust (1992) evaluated yellow poplar and sweetgum structural lumber with metal plate connectors using load/deflection parameters and found them suitable for use in trusses. Moura et al. (1995) did research on the effects of wood density on metal plate connections under cyclic loading and they found that joints using high density wood usually are not much more rigid but can handle 30 percent greater load than joints made with low-density wood. On the other hand, they noted that wood density does not affect mechanical behavior (static and fatigue) of the joint which indicates that for any wood density, the connector horizontal displacement is responsible for the decrease in stiffness and increase in vertical slip of the joint. Quaile and Keenan (1979) mentioned that the strength and stiffness of truss plate joints might be affected by size and number of teeth, size of the plate, plate orientation, grain orientation of the lumber underneath the plate, species, specific gravity, moisture content, pressing forces for the joint, elapsed times between joint fabrication and testing, tensile and shear strength of the metal plate. Gebremedhin and Crovella (1991) used four different plate types and performed an analysis of error propagation. They found that the largest error was introduced by the variability in the foundation modulus of the wood. This is calculated by multiplying a constant times the MOE of the wood (surrounding the beam) and by the moment of inertia of the tooth. Tankut et al. (2004) reported that full-cell treatment of Timberstrand LSL with fire retardants resulted 17% reduction on MOE and 20% reduction on MOR values and moderately higher swelling characteristics compared to control specimens.

Currently, the design and testing of metal plate connected wood trusses and joints are done according to the Design Specifications for Metal Plate Connected Wood Trusses (ANSI/TPI 1-2014; and ASTM D-1761-88) standards. Gebremedhin et al. (1992) concluded that the joints tested in tension showed failure types for different angles which were related to the grain of lumber. For $9 \sim 0^\circ$ it was plate shear failure, and for 30° and 45° it was tooth withdrawal and for 60° and 90° it was wood failure. The joints tested in shear showed that the failure type for 0° , 30° and 45° it was tooth withdrawal and for 60° and 90° it was plate shear at the joint interface. Stahl et al. (1996) recommended that plate buckling should be treated as a truss design limit similar to plate pullout or wood member failure. In this half-century, especially in United States, metal plate connectors and joints have become very important in building construction. The first of today's form of metal plate for connecting wood members was introduced by Juveit in 1955 (Meeks, 1979). According to Hoover (1996) in the mid-1950's metal plate connected wood trusses were developed by Carol Sanford and they have been widely used ever since. Today 80% of homes use metal plate connected wood trusses in floor systems or roofing applications.

MacArthy and Wolfe (1987) conducted research to derive the parameters needed to apply Foschi's truss joint model and found that the fit between the model and the individual experimental curves was quite good. They used 20-gauge 3 "x5" plates with a tooth length of 3/8" and a tooth density of 8 teeth per square inch. They also reported that the load-displacement curves of the tested joints were not significantly affected by elastic strain in the plate. They indicated that joint performance was not affected significantly by modulus of elasticity (MOE) of the lumber and concluded that there is no need for different parameter values for the different MOE categories of truss grade lumber. McAlister (1989) performed several tests using southern pine laminated veneer lumber (LVL) and composite (veneer edged Douglas-fir) 2 by 4s, all having comparable specific gravities. He concluded that for a given truss plate connector, there was no practical difference in load at critical slip or ultimate load between these two types of truss framing. He also mentioned that the Foschi/Triche load deflection formula and curve parameters were in close agreement with, the actual values of all types of truss framing tested with 20 -gauge plates. Moreover, they noted that the curve parameters for the composite, the LVL and the Southern-Pine had similar values among the various plate types tested. O'Regan (1998) et al. recommended the following design equation, which will ensure that the joint will ultimately fail in the steel-net section. McAlister and Faust (1992) performed truss plate tests using yellow poplar and sweetgum 2 by 4 * s. They compared the results with southern pine laminated veneer lumber and southern pine No.1 KD 2 by 4's and found that the values for maximum load per tooth and load per tooth at critical slip were essentially the same for southern pine LVL, yellow-poplar and sweetgum. They concluded that yellow poplar and sweetgum are suitable for use in trusses based on their fastener performance.

McKenna (1979) evaluated LVL with metal plate connectors and indicated that larch and red pine LVL exhibited satisfactory performance (94.3% of solid southern pine when used with same type of plate) and were suitable for truss manufacturing. He also noted that the spruce and white pine LVL did not exhibit performance that would be economically acceptable. Holcomb (1982) conducted research, regarding metal plate connected Douglas-fir LVL and southern yellow pine and explained that southern pine joints were superior based on stiffness when compared to LVL that had lower specific gravity- He also added that the most common form of failure was plate peel accompanied by tooth withdrawal, and that some of the LVL fractured in glue line related wood failure. Tooth failure was observed with 20 gauge narrower plates and plate failure occurred with regular 20-gauge plates using southern pine. Also he indicated that the heavier gauge plate material provided greater resistance against plate peel than was offered by lighter gauge plate. He concluded that it was entirely possible that LVL made from New York State plantation grown conifers could be used as a substitute for commercially sawn dimensional lumber used in the fabrication of wood trusses. Ginis (1985) thesis regarding tensile and shear behavior of LVL (metal plate joints in LVL manufactured from commercially cut southern yellow pine veneers) , determined the behavior of LVL-metal plate joints when the metal plate was bonded to the LVL surfaces as well as embedded in the LVL. He concluded that LVL performed similar to or better than solid Southern yellow pine which means, that LVL has a potential for use in the truss fabrication industry and that gluing the metal plates gave better results.

Güntekin (2009) carried out a research on metal plate connected Calabrian Pine truss joints. He indicated that Turkish Calabrian pine (*Pinus brutia*) is a suitable raw material and can be used for truss manufacturing. The test results showed that method of loading and plate size significantly effect the ultimate strength, load at critical slip and stiffness values of the joints.

Timberstrand laminated strand lumber (LSL) is an engineered high-performance lumber that is produced from logs that are not large, long or straight enough to be of structural value in conventional wood products. Timbers LSL is produced from fast grown species such as aspen or yellow poplar. The proprietary manufacturing process utilizes approximately 12" long strands of wood fiber bundles bonded with special resins and cured with a steam injection process to produce large billets of lumber up to 48' long, 8' wide and 5-1/2" thick. These billets are then cut to meet given specifications (Truss Joist Macmillan, 1999). Timberstrand applications include rim boards or rim joists, wall studs and plates, millwork core material, headers and beams (Weyerhaeuser, 1999). The resin used in Timberstrand LSL (MDI-polyurethane also called isocyanate) has no formaldehyde, so off-gassing is not an issue (Weyerhaeuser, 1999).

The objectives of this study are the: 1) Investigating the performance of metal plate connected Timberstrand joints under tension and shear forces, 2) Comparing the results of metal plate connected southern pine joints under the same loading conditions, 3) Evaluating the failure modes of specimens.

2. MATERIAL AND METHODS

The procedure for this study was carried out in accordance with the ANSI-TPI/1-95 (1995) specifications and ASTM D-1761/88 (1988) standards.

2.1 Preparation of the Test Material

Timberstrand LSL used in this study was produced by Truss-Joist Macmillan MacMillan. Twelve pieces of LSL were purchased from a local supplier, located in Syracuse NY, USA with the dimensions of 1.5 "x3.5 "x8'. The moisture content was approximately 6% (measured by hand held dielectric type moisture meter) when purchased. Southern pine dimensional lumber, which was kiln dried-No 2 dense, was also purchased from the same supplier with the dimensions of 1.5"x3.5"x12'. The moisture content of the southern pine was approximately 8% when purchased. The metal plates used in this study were obtained from Alpine Engineered Products Inc., which are sold commercially as "Wave Plate" brand (Figure 1. A.) because of their unique wave shape tooth pattern design. Their physical properties are shown in table 1.

In order to decide which plate should be used, different types (16, 18, and 20 gauges), and brands of plates were evaluated by embedding the plates into Timber strand and burning the wood off of the assembly. Following this, a visual inspection was conducted which was based upon the assumption that embedded bent teeth possess less resistance to applied loads. After counting the bent teeth of all the plates embedded, it was decided that Alpine wave plates gave satisfactory results (6 out of 72 bent teeth (8.3%) comparing to 35% or more bent teeth for others). Tooth deformation performance can be seen in figure 1. B.

Table 1 Properties of the metal plate used in this study.

Thickness	140 mm	Width Of The Slots	3.05 mm	Number Of Teeth	72
Gauge	20	Length Of The Slots	12.7 mm	Cross Sectional Area Across Width	70 mm ²
Width	1200 mm	Length Of Tooth	9.14 mm	Yield Strength Of The Steel (Alpine)	33000 psi.
Length	1200 mm	Shape Of Tooth	V	Ultimate Tensile Strength Of The Steel (Given By Alpine)	45000 psi.
Plate Area	7.5x7.5 cm	Number Of Teeth /In2	8		

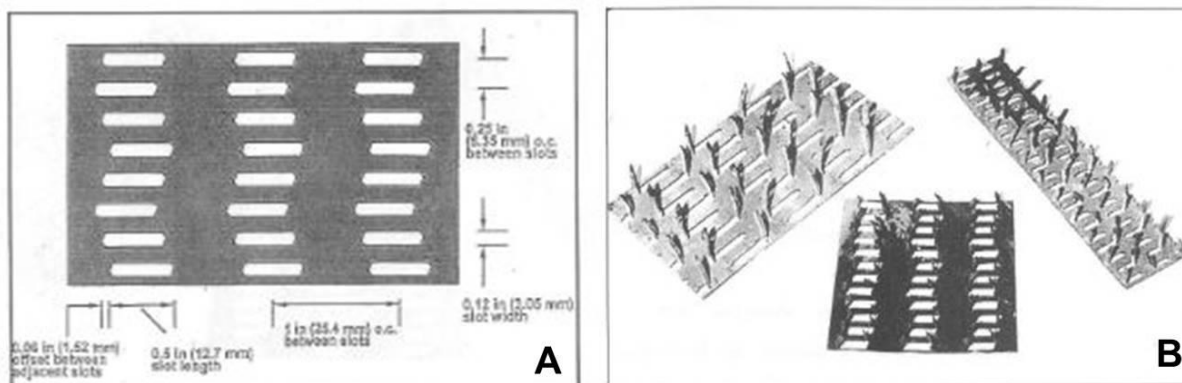


Figure 1 A. The wave plate manufactured by Alpine (BOCA, 1997), B. Some of the burnt metal plate connectors. From left to right, 16-gauge, 20 -gauge Alpine and another 20 gauge.

2.2 Conditioning

Uncut Timberstrand and southern pine lumber were stickered in a controlled conditioning room, which had 56% relative humidity and 60°F temperature and stored until the fabrication of the joints began. They reached the equilibrium moisture content of 10% in three weeks. The moisture contents of the materials were determined by cutting a number of small specimens and weighing them at certain time intervals (every 6 hours) and monitoring the change in weight of the particular sample. Once the weight change was found to equilibrate small samples were cut and the actual moisture content was determined based on the oven dry weight which was evaluated by drying the samples at 210°F for 48 hours and noting the weight at the end of this period.

2.3 Fabrication

The southern pine and Timberstrand lumber was cut to 1.5"x3.5"x24" and 1.5"x3.5"x9" sizes for use in fabricating tension and shear test specimens respectively. The tension test requires the plate axis to be perpendicular to the grain of the wood in the joint configuration. This orientation was chosen because of the unique design of the wave plate. Alpine "wave" plates (20 gauge) were embedded into Timberstrand and southern pine lumber. Each joint was replicated 5 times. Each specimen was fabricated by pressing two metal plates into the two members of the joint. To keep the wooden members properly aligned a clamp was used at both ends of the assembly. This also maintained the correct placement of the plates.

The plates were pressed into the wood members one side at a time. The Baldwin Emery testing machine Room 110 Baker Lab. was used for pressing the plates. They were carefully embedded and pressing was stopped when the plates were visually observed to be embedded completely (less than 1/32" left on the surface). The specimens were then placed in the conditioning room (56% relative humidity at 60 degrees) again and stored until the testing began.

2.4 Testing

The specimens were tested using the Young testing machine that is shown in figure 2. A. and B. Two digital linear variable differential transformers were placed at the wood member-to-wood member connection area. To avoid slippage of the wood within the tensile grips, rectangular shaped sandpaper was glued onto southern pine solid wood pieces placed at the grip region. Titebond™ PVA based commercial glue was used for this application. Uniform loading rate (0.035"/minute) was applied throughout the test.

Displacement readings were taken by the computer automatically from the two linear variable differential transformers as seen in figure 2. A. and B., which were calibrated before testing. The average value of two readings was used as the value of wood-to-wood slip of the specimen across the joint. The ultimate load, the load at the critical slip (0.015") and the testing duration were also recorded. Small specimens were cut from the assemblies after testing to determine the specific gravity and moisture content of each.

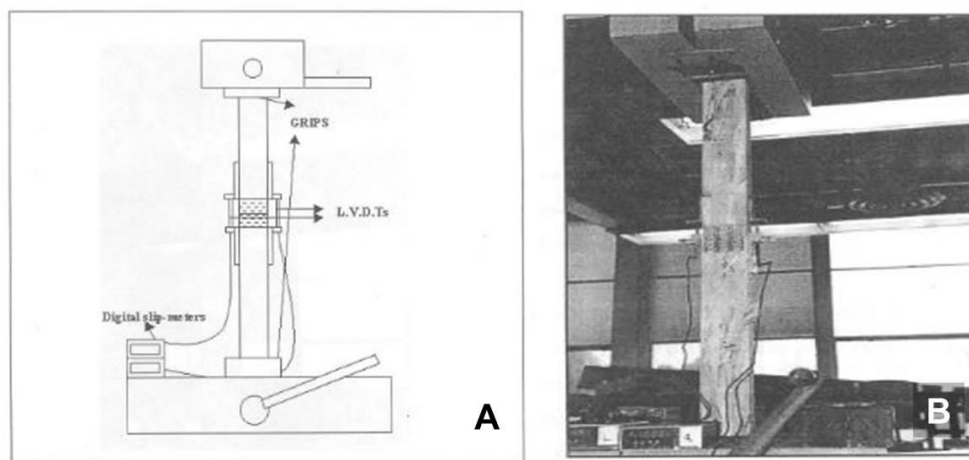


Figure 2 A. Diagram of tension test using Young machine, B. Tension casting of Timberstrand /Metal Plate specimens.

The shear test program included testing of Timberstrand and southern pine with three different angular orientations of the plate. The angles were 0°, 45° and 90° (Figure 3. C.). Five replicates for each angle were tested. Angle "a" is the angle of inclination between wood joint in test sample (placed vertical) and length of metal connector plate

(ANSI/TPI-95). The plates (3"x3") were placed very carefully in order to have an equal number of teeth in both sides of the wooden members. Because of necessary overlapping in the 45-degree angle tests, the plates had to be placed with a one-inch vertical offset on two sides of the joint. The plate positions were reversed on opposite sides (Figure 3. A.).

The shear test specimens were fabricated in a similar way to the tension test specimens. The main difference was that three wooden members were used. The Baldwin-Emery machine was also used for embedding the plates. Two plates were pressed simultaneously into the members one side at a time. Then, the specimen was flipped over and the other two plates were pressed. A clamp, which was placed on both sides, was also used to maintain the stability of the embedding process. The specimens were then placed and stored in the conditioning room (%56 Relative humidity at 60°) for a period of one month. The Tinius-Olsen universal testing machine was used for testing shear specimens. They were placed perpendicular to the testing machine's platens as shown in figure 3. B. A uniform loading rate (0.035"/minute) applied throughout the test. The ultimate load to failure and failure type was recorded.

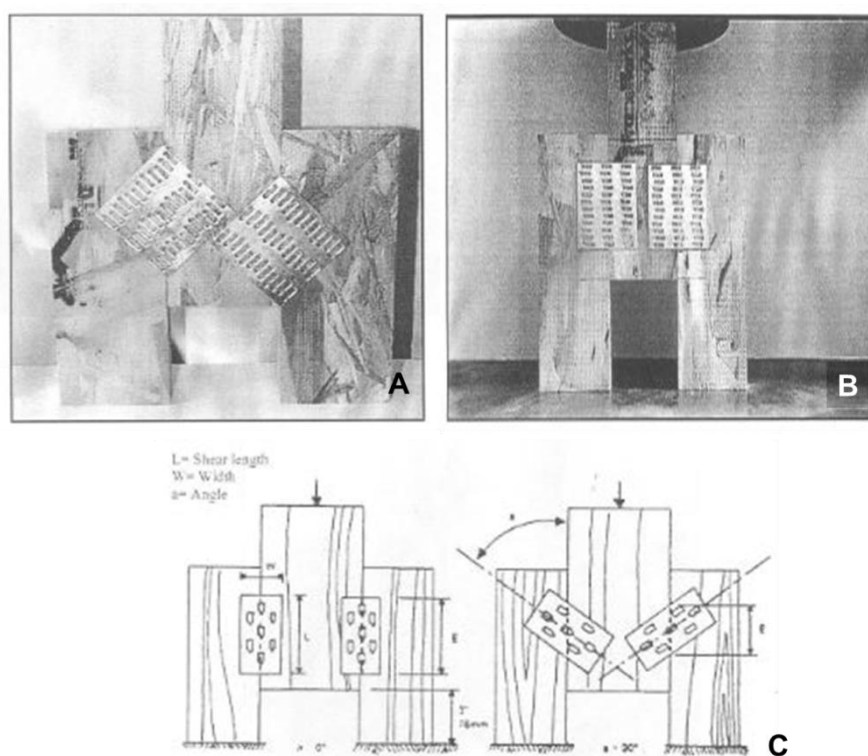


Figure 3 A. Shear test with the angle of inclination (ANSI/TPI), B. Shear testing specimen with 45°-plate orientation, C. Shear testing of LSL lumber with plate orientation of 90°.

3. RESULTS

Load-slip data, as well as moisture contents and specific gravity data which was obtained by cutting small specimens after testing, were collected and analyzed. For LSL, the specific gravity was found to be 0.66 with 1.5% coefficient of variation (%C.V.) and the moisture content was %8.7 with a 2.3% c.v. For the southern pine, specific gravity was 0.53 with 4.2% C.V. The average moisture content for southern pine was 10.5% with 3.9% C.V. It can be seen from

the data that there is a significant difference, (%25 higher specific gravity), based on comparing specific gravity values.

The load-slip curves were used to evaluate the stiffness and the performance of the joints. According to the data, the load-slip curves exhibited nonlinear relationships. Most of the curves' beginning sections can reasonably be characterized as linear and the slope of the load-deformation curve also seems to go toward zero at the ultimate load. In figure 4. A. and B., each figure represents five specimens and their tension tests' load slip data. It can be seen that in Timberstrand for most of the cases the curves' initial slopes (from the curves between 500 and 1000 lbs.) are similar (average initial slope 549207 lb./in. at 26% c.v.). This means that there is not much variation among Timberstrand specimens. For southern pine (except specimen sp11 which had significant amount of slippage during testing and was neglected for calculating initial slopes and load at critical slip), it can be seen that there is a significant difference between curves (average initial slope 292104 lb./in. at 58% C.V) This difference can be explained by the broad variations of the physical characteristics of southern yellow pine lumber.

Examining the load-slip data, it can be observed that the Timberstrand had considerably steeper (88% higher average initial slope) curves than southern pine. This means that Timberstrand metal-plate-connected joints have higher stiffness than southern pine joints. According to TPI (Truss Plate Institute) the load at critical slip (0.015") and ultimate load determines the overall behavior of the joint. This means that TPI does not consider the stiffness of the joint as the critical factor.

Summary data of the ultimate loads and loads at the critical slip of 0.015" with the associated standard deviations and coefficients of variations are shown in Table 2. It can be seen from the average values, that Timberstrand laminated strand lumber was superior (51% higher ultimate load) based on tensile load carrying capacity. This can be explained by its higher specific gravity (25% higher than southern pine) and higher tooth holding capacity.

According to Foschi's formula, the average tooth holding capacity at the critical slip (0.015") would be 58.29 lbs. per tooth for Timberstrand and 33.57 lbs. per tooth for southern pine (Table 3). Comparing these results with actual values reveals that Foschi's theory is in close agreement with the actual experimental results. (58.29 lbs. (formula) vs 54.37(actual), and 33.57 (formula) vs. 33.16 (actual)). it is valuable to compare the results with Gebremedhin et al. (1992). They used southern pine and 3"x5" 20-gauge plates for the tests, and they found that southern pine joints, which had 17.7% moisture content, with 90 plate orientation had 4200 lbs. ultimate load with 16% c.v. Similarly, Timberstrand joints performed better (10% higher ultimate load) than southern pine joints.

Table 2 Average values of tension test for 5 replicates.

Specimen	Average Ultimate Load (N)	Std Dev. (N)	C. of V%	Average Load (N) At critical slip (0.38 mm)	Std.Dev. N	C. of V%
LSL	20568	3082	15	17414	2548	14.7
S.pine	13540	2802	21	10631	2682	25

Table 3 Average experimental (Foschi's) curve fitting values of tension test.

	P critical N / teeth	Average K N/mm	Average Mo Lbs./teeth	Average Mi N/mm
Timberstrand	58.29	1336.04 26% c.v.	43 .27 16% c.v.	231.34 35% c.v.
Southern pine	33 .57	710.48 58% c.v.	29.44 24% c.v.	105.07 43% c.v.

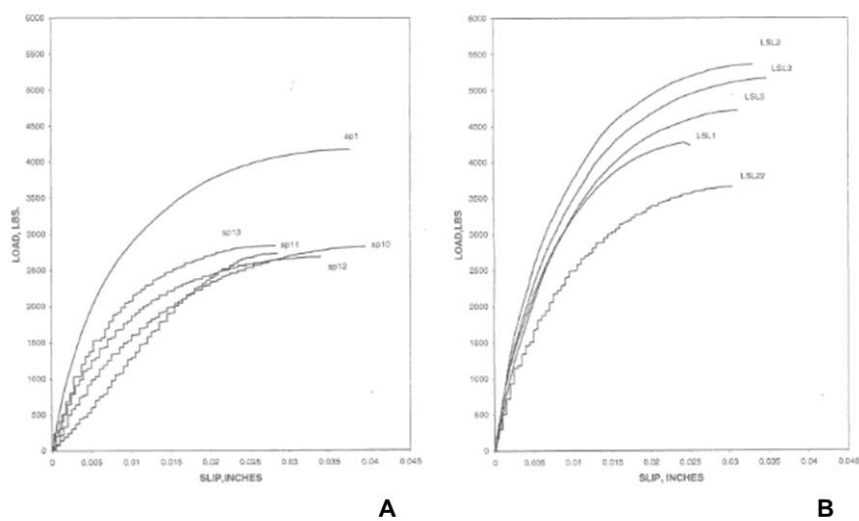


Figure 4 A. Load Slip Curves of Timberstrand /Metal Plate Tension Tests, B. Load Slip Curves of Southern Pine/Metal Plat Tension Tests

Failure modes give information about why the assembly failed. Because of this observation, it is a very important part of the overall discussion of connection performance. Plate peel accompanied by tooth withdrawal was the most common (four out of five) form of failure observed. Clean tooth withdrawal was observed for most of the specimens. This can be explained by the fact that wood strand to wood strand bonds are greater than metal plate strength in bending and withdrawal. This mode of failure is shown in figure 5. B. Failure of one (one of five) of the LSL specimens was observed to be different. In this case, the plate's withdrawal forces overcame the wood members tooth holding forces with the result that chunks of wood (15% of the connection area) remained between the teeth, tearing the wood across the grain as shown in figure 5. A. Southern, pine specimens showed no visible or very minor (less than 5% of the area) of the chunking action noted above.

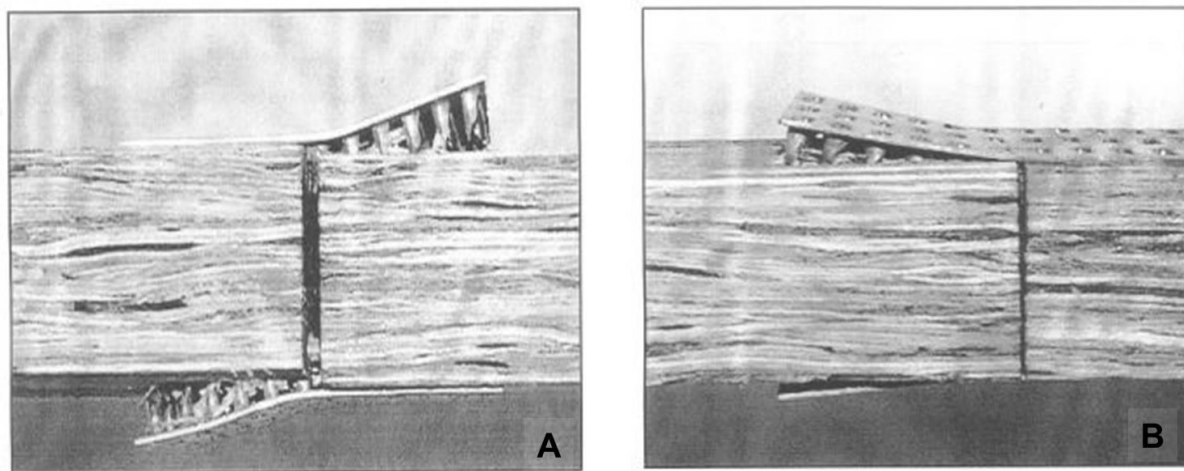


Figure 5 A. Tooth withdrawal type of failure, B. Tooth withdrawal (with very little chunking) failure

This type of test evaluates the effective shear resistance of the net section of truss plates for different angular plate orientations. Effective design values in shear (pounds per linear inch) for a single metal plate (V_s) are determined with Equation 1 and 2 (ANSI/TPI 1-95(1995)).

$$V_s = R_s F_v t \quad (1)$$

where:

R_s = shear resistance effectiveness ratio (F_{sp}/F_s)

F_v = basic allowable shear stress (13200 psi = $F_y 0.40$)

F_y = minimum yield strength of the metal

t = thickness of the plate

F_s = ultimate theoretical shear stress of the solid metal control specimen. (25955 psi = $0.577 F_{tc}$)

F_{tc} = ultimate tensile stress of the metal (45000 psi.)

F_{sp} = ultimate shear stress of the plate

According to ANSI/TPI 1-95 (1995) the ultimate shear stress is determined as,

$$F_{sp} = F_{sp}/4A_{gp} \quad (2)$$

F_{sp} = ultimate shear stress (N/mm²)

P_{sp} = maximum load

A_{gp} = gross cross-sectional area of each metal connector plate specimen which can be calculated by multiplying the thickness of the plate by shear length (length of metal control plate parallel to the longitudinal axis of the area from which the metal control plate teeth were sheared) of the plate.

The average ultimate load values (Tables 4 and 5) were used to calculate the effective shear resistance values (Table 6). Shear lengths for 0° and 90° were 3 inches and for 45° specimens it was 4.24 inches. It can be seen from the data that Timberstrand joints were superior to southern pine joints at all orientations, based on their shear resistance. It can also be observed from the data that 45° orientations had substantially higher ultimate loads than the others did. However, the 45 orientation did not have the highest effective shear resistance. It is seen that, the 90° orientations had the lowest ultimate loads. It is interesting to compare the results with Ginis (1985) who conducted his research using southern pine LVL (0.53 specific gravity) and 3"x5" 20-gauge plates (some of them glued onto wood members). He found that for unglued 0° orientation, average ultimate load for shear stress was 5320 lbs., for 45° it was 5852 lbs., and for 90° it was 3744 lbs. For glued specimens, the values were 0° -6556 lbs., 45°-7232, and for 90° orientation it was 4432 lbs. According to the comparison of this study's data with Ginis (1985) it can be said that Timberstrand performed better than LVL.

Table 4 Ultimate load for shear tests of Timberstrand specimens.

Angle	Average Ultimate Load N	Std.Dev. (N)	C. of V. %
0°	30977	1699	5.49
45°	34589	2482	7.18
90°	23931	2428	10.15

Table 5 Ultimate load for shear tests of southern pines specimens.

Angle	Average Ultimate Load N	Std.Dev. (N)	C. of V. %
0°	27739	1120	4.04
45°	28682	2055	7.16
90°	21084	3589	17.04

Table 6 Effective shear resistance values.

Angle	Timberstrand Effective Shear Resistance Values N/mm.	Southern Pine Effective Shear Resistance Values N/mm
0°	51.625	46.2
45°	40.6	33.78
90°	39.72	35

The failure modes give important information regarding why the joint assembly failed. The failure modes observed in this study were wood failure (Figure 6.A.), net-section failure (Figure 6B) and tooth withdrawal (Figure 6C). Tooth withdrawal accompanied by peeling of the plate was the most frequent failure observed in this study. This type of failure occurred mostly at the 0° and 45° orientations. One out of five of the Timberstrand joints failed with some small amount of chunking of the wooden members. Wood failure of the Timberstrand was observed only at 90° orientation, which occurred in one out of five of the specimens and gave substantially lower results (16%) than the average ultimate load result. Wood failure was also observed for one of southern pine specimens, which gave a very similar result. At the orientation of 90°, Timberstrand joints failed at the plate's net section (shear failure in the plate). According to Ginis (1985), this could be expected because of this specimen type having the smallest net cross sectional area among all orientations.

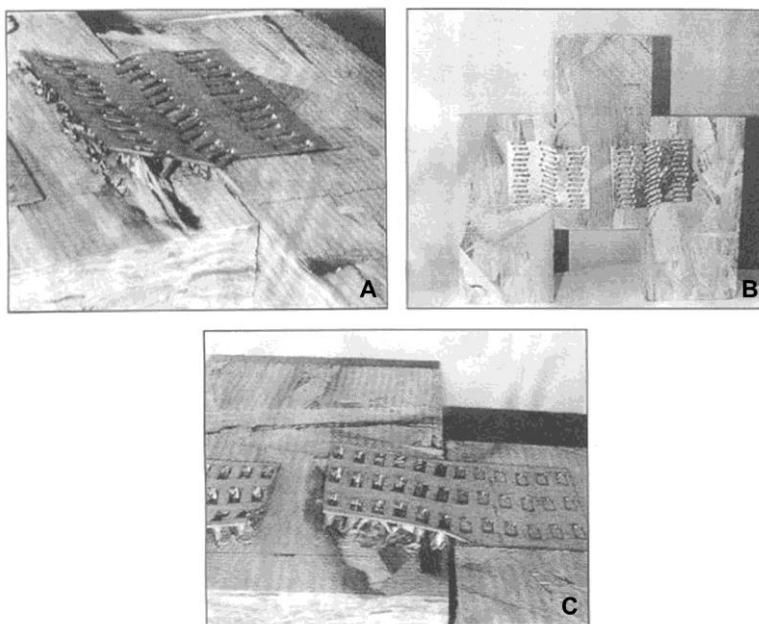


Figure 6 A. Wood failure in shear testing, B. Steel net section failure in shear testing, C. Tooth withdrawal failure in shear testing

4. CONCLUSION

The behavior and the performance of metal plate connected Timberstrand connectors loaded perpendicular to the grain in tension and shear at 0°, 45° and 90° orientations has been examined. According to the test results, Timberstrand joints performed 51% higher in tension loading and 14.83% higher in shear loading than solid southern pine joints. The burning test revealed that most of the metal plates manufactured do not appear to be effective for

use in Timberstrand except Alpine waveplate. Therefore, it is the opinion of the author that further research is needed to find the right type of metal plate for use in various LSL types of composite materials. Finally, it is concluded that further research should be conducted with laminated strand lumber with different metal plate connectors and orientations. It would be really interesting to know the performance of Timberstrand truss joints under different moisture conditions because of the swelling tendency of LSL. Furthermore, creep behavior of the joints should be studied. Also, full size trusses of Timberstrand should be tested before any introduction of this material is made by the truss industry. Timberstrand, which has many environmental advantages, is an excellent alternative timber material to the current predominantly solid southern pine based truss fabrication industry.

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