USING SALVAGED LUMBER AS A FEEDSTOCK FOR MANUFACTURING STRUCTURAL GLULAM

By

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ABSTRACT

USING SALVAGED LUMBER AS A FEEDSTOCK FOR MANUFACTURING STRUCTURAL GLULAM

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Every year tons of old wood end up in landfills as there is no lucrative alternative. A glued-laminated timber section made with salvaged lumber could make efficient use of the salvaged material. A 3-point bending test was conducted on a total of 120 specimens to investigate the mechanical properties of glued-laminated timber manufactured using salvaged lumber. The MOE, MOR, and reliability of the salvaged lumber were assessed according to the experimental results. The influence of the position of salvaged lumber on the MOE and MOR of glulam was investigated by one-way ANOVA. The influence of the type of adhesive used for manufacturing glulam was also studied. The results show that that when compared with control samples of glulam, the glulam manufactured with 60% of salvaged lumber had a reduction of 10.5% in MOR, 10.5% in MFL, and 1.9% in MOE as shown in table 4.1. when compared with control samples of glulam the glulam manufactured with 40% of salvaged lumber had a reduction of 4.7% in MOR, 4.5% in MFL, and 1.35% in MOE. These reduction percentages are less than 11% for all mechanical properties. In other words, we can say that even for glulam samples made of 60% of salvaged lumber the reduction percentage for all mechanical properties is going to be less than 11%. The reduction percentage for MOE between two consecutive grades turns out to be 33% approximately so we can safely say in absence of any data about a given salvaged sample we can assume that MOE of that salvaged lumber will be one grade below the actual MOE of that sample before use.

ACKNOWLEDGEMENTS

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INTRODUCTION

1.1 Overview

The past few years have seen exponential growth in sustainable building practices. Until recently, relatively less importance was given to the reuse of salvaged lumber for structural applications. Reusing salvaged lumber helps in reducing greenhouse gas emissions, reducing carbon footprint, minimizing pollution, and conserving natural resources (Bergman et al., 2013; Rose et al., 2018). Building deconstruction is an accepted method to extract the maximum amount of good conditioned salvaged material from old buildings and old structures (Tatiya et al., 2017). The use of salvaged wood is not a new concept, but it has seen a surge in popularity especially with sustainable and green building construction. Figure 1.1 shows the frequencies of salvaged wood and virgin wood terms used yearly found in sources printed between 1500 and 2010. There is an increase in the use of the word salvaged wood after the year 2010. Salvaged wood is the wood that is carefully extracted from the old structure during its demolition or deconstruction. This salvaged wood is then cut or re-shaped for its reuse.

The emerging concept of Story wood has huge potential to add value to the salvaged wood in the coming years. Additionally, these Story wood can be used to score points in LEED and WELL certification by contributing to the innovation, materials, and mind categories (Delta Institute, 2018). Another major benefit of reusing this salvaged lumber is that the material can be dimensionally stable, as it has been air-dried for many years. Despite having several advantages of reusing salvaged lumber, its widespread use is hampered because of fewer consistent markets for large volumes of wood waste.

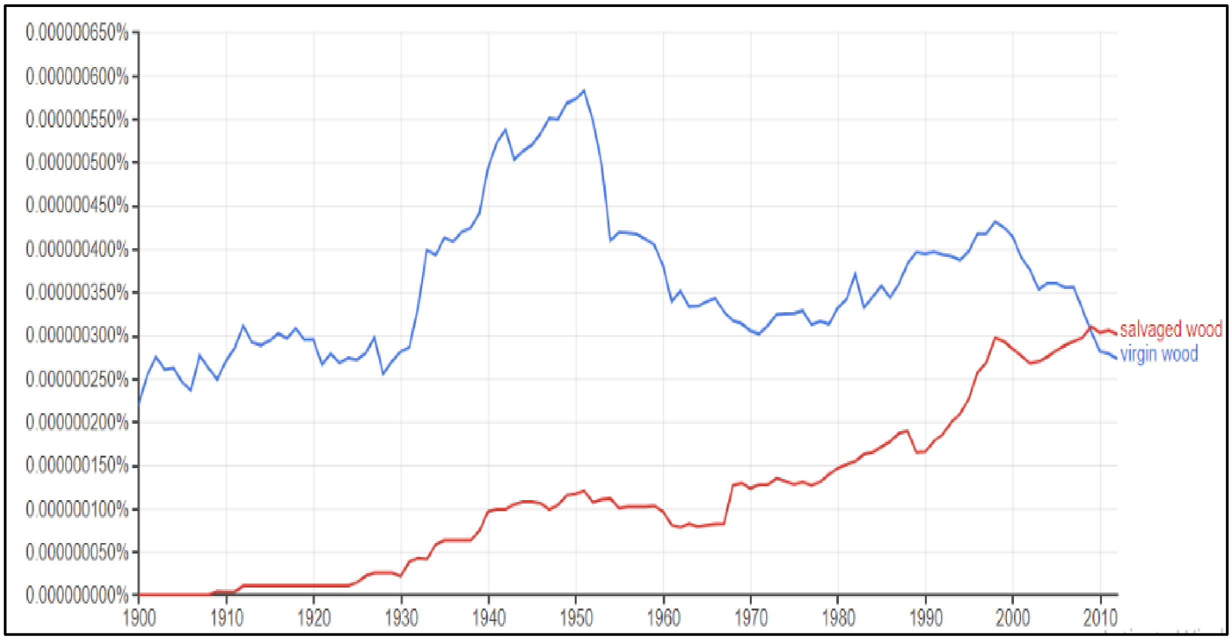


Figure 1.1: Google N-Gram: Graph showing the frequencies of salvaged wood and virgin wood terms used yearly found in sources printed between 1500 and 2010.
Source: Figure N-Gram

Despite beneficial features, the reuse of salvaged lumber faces barriers as well. One of the main barriers for reusing the salvaged wood is that if the wood is exposed to unfavorable conditions such as direct sunlight, UV radiations, or humid climate the wood undergoes chemical and physical degradation (William et al., 1984) Due to temperature fluctuations and humidity wood is subjected to mechanical stresses (Borgin et al., 1975). Elevated temperature for a longer duration may also result in loss of weight, the strength of wood, and decrease of MOR (Forest Product Laboratory, 1999). Also, if the wood is subjected to loading for a long period, then wood is likely to carry a lesser percentage of load when compared to the load-carrying capacity of the same wood subjected to no-load previously. For example, a wood subjected to bending stress for 10 years may be capable of carrying only 60% or less load than the same wood which is not subjected to any bending stress in past (Forest Product Laboratory, 1999). Therefore, effects on strength of wood due to the loading history of the wood must be considered when salvaged wood is to be reused. However, Barret and Foschi (1978) presented a model to predict the effects of duration of loading on wood, which suggested that a wood member placed under a constantly high-stress level over a period then the wood is likely to sustain damage due to the DOL effect as the rate of degradation is expected to slow down over a period.

Other barriers to increased wood reuse include the lack of recycling centers for wood waste and the lack of a cost-effective system for re-grading salvaged lumber (Howe et al., 2013). Lack of a dedicated process for handling hazardous wood (such as wood painted with lead-based paints) contributes to the list of barriers as well. Another barrier is the difficulty in estimating the exact volume of post-consumer wood waste. Essential steps are required to be taken to remove the barriers to expanding markets for reusing wood waste as reusing wood waste is necessary to overcome several problems as well.

1.2 Need Statement

Every year, 146 million tons of solid waste is disposed of in landfills across the United States (EPA., 2018). This waste mainly comes from residences, industries, and construction sites. One of the major sources of waste wood is demolished structures. In USA there are almost 226,778 abandoned houses that are potential candidates to be demolished (US CENSUS BUREAU, 2020). This large amount of wood from these abandoned houses are most likely to end up in landfill if any lucrative alternative is not provided. Land filling of wood from houses will not only end the life cycle of a renewable material but will also use up the limited landfill areas available in the US. Wood is one of the oldest construction materials and is a renewable resource (Issa, 2005). Despite being renewable, it is still the second-largest contributor to construction and demolition (C&D) debris after concrete. Wood waste contributes 20 to 30 percent of the total C&D waste and 10 percent of all landfilled material annually (Leblanc, 2018). Problems associated with landfilling, waste incineration, and economic strain due to an increase in the cost of waste disposal are of growing concern. Growing awareness about environmental issues related to landfilling of wood waste and burning of wood as a biofuel has pushed researchers to contemplate on reuse and recycling of wood. As per the Steel Recycling Institute (SRI), the rate of steel recycling is 98% and the rate of concrete recycling is 82% which is notably higher than the recycling rate of wood which is only 16.7%. (EPA, 2017; CMRA, year). These statistics make it evident that despite having both renewable ability and abundant availability of wood, its recycling percentage is very low. Hence, it is vital to elucidate that the reuse of wood should be our priority rather than the increasing consumption of virgin wood exponentially. To address the issues of wood waste management, research must lead to the creation of new markets for waste wood material in US.

1.2.1 Wood Waste Management in the United States

The United States is currently the largest producer of wood products in the world. A total of 143 million tons of wood products are produced in the US each year (Howe et al., 2013). Forest products are consumed at a rate of 1,800 pounds per person annually in the US (Haynes, 2003). It is forecasted that the consumption of forest products in the U.S will be escalated by 40 percent by 2050; to meet this demand, a 23 percent increase in timber harvest will be required (Haynes, 2003). And as per the World Bank's forecast, global timber demand is going to quadruple by 2050 (FIM, 2017). Reusing salvaged lumber will be of a great benefit to fulfill the growing demand without overusing the existing forest reserves. The forecasted growth rate of the global reclaimed lumber market is 4.8% which will boost the USD amount from 12.50 billion in 2019 to USD 17.79 Billion in 2027 (Research and data, 2020). Promotion of the concepts like Story wood and reusing salvaged lumber for manufacturing products like CLT and Glulam will help in reducing pressure on forest reserves to fulfill future demands of wood supply. Reusing salvaged lumber will not only reduce the overuse of forest reserves but will also help in reducing the wood waste generation.

Typical markets of wood waste in the U.S. include paper products, animal bedding particleboard, landscaping material, pulp, composting material, energy recovery, and reuse (Calrecycle, 2019). In the US approximately 30 percent of wood waste is commonly disposed of by burning wood for energy, 10 percent is ground into mulch, and the remaining 60 percent is disposed of in C&D landfills. (Calrecycle, 2019). Greenhouse gas (GHG) emissions from landfilling of wood waste are comparatively greater than GHG emissions resulting from burning of old wood for energy (Bergman, 2013). Several strategies are required to increase the efficient use of wood utilization. One such strategy which will help in the efficient use of wood utilization is the concept of wood cascading. In general, wood cascading means efficient utilization of wood at every product stage with its use for energy generation as the final stage. (Risse, 2019). Figure 1.2 shows one such example of wood cascading for a circular economy.

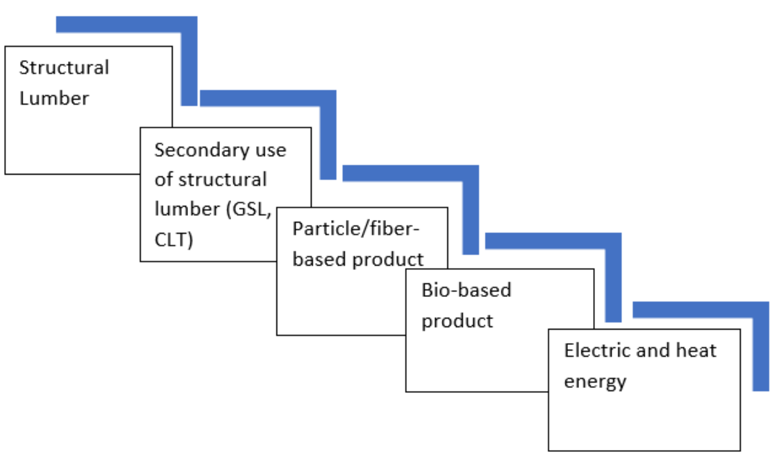


Figure 1.2: Wood Cascading of Structural Lumber

In 2017, the domestic generation of wood in the municipal solid waste (MSW) stream was approximately 18 million tons; this is approximately 6.7 percent of the total MSW generated that year. Out of these 18 million tons, 12.1 million tons of wood ended up in landfills (EPA, 2017).

Management Pathway	1960	1970	1980	1990	2000	2005	2010	2015	2016	2017
Generation	3,030	3,720	7,010	12,210	13,570	14,790	15,710	16,300	18,050	17,990
Recycled	-	-	-	130	1,370	1,830	2,280	2,660	2,940	3,000
Composted	-	-	-	-	-	-	-	-	-	-
Combustion with Energy Recovery	-	10	150	2,080	2,290	2,270	2,310	2,570	2,860	2,850
Landfilled	3,030	3,710	6,860	10,000	9,910	10,690	11,120	11,070	12,250	12,140

Table 1.1: Shows the data of the wood generated, composted, combusted with energy recovery, and landfilled by weight (in thousands of U.S. tons) in the year 1960-2017(EPA, 2017).

Source: Center for Forest Products Marketing and Management (Virginia Polytechnic Institute)

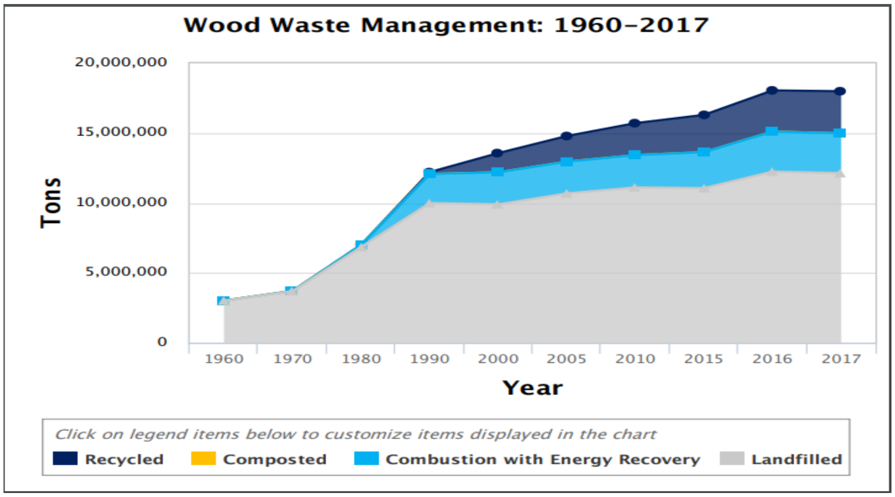


Figure 1.3: Wood Waste Management: 1960-2017
Sources: https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/wood-material-specific-data#WoodTableandGraph

1.2.2 Potential Supply of Structural Wood Waste in the US

There are 16,672,938 homes in the United States; out of those homes 5,884,047 fall under the "other vacant" category which is the best estimate for abandoned homes in the US (US Census Bureau, 2019). In five years (2013-2018) alone 585,233 homes became vacant (US Census Bureau, 2018). These abandoned houses are required to be deconstructed so that all useless siting salvageable wood can be reused again profitably. It is estimated that total abandoned homes in the US have approximately 28,205,676,000, board feet of salvageable lumber which can be reused. (MSU center for community and economic development, 2016; US Census Bureau, 2016). These abandoned homes are a stockpile of old lumber which can be reused to prevent these old lumbers from losing the potential salvage value. A significant amount of lumber is potentially available for future reuse. Since the 20th century, more than 3 trillion board feet of lumber have been sawn in the United States (Falk et. Al., 2013; Howard 2001). Some states in US are facing issues of abandonment on a greater scale. The state of Michigan is one of such states who are facing problem of abandonment which needs to be addressed as soon as possible.

1.2.3 Potential Wood Waste Supply in Michigan

As per the U.S census bureau, Michigan had 671,430 housing units in 2018, with approximately 223,774 of those being abandoned (Census Bureau, 2019). In five years (2013-2018) around 9,347 homes were abandoned in the state of Michigan. (Census Bureau, 2018). The City of Detroit alone has over 78,071 abandoned homes (US Census Bureau, 2019)). Structural abandonment poses several threats to communities, such as economic loss to neighboring non-abandoned properties, increased crime, and unemployment rates, decrease in property value, impact the aesthetics of the surrounding area, pose a negative impact on public health and community. (Mallach, 2018). Due to these negative impacts abandonment of homes has become a major concern for local government. These abandoned homes in Michigan have littered the state. One of the best methods for solving this issue is the deconstruction of these abandoned homes instead of demolition (Mallach, 2018). Deconstruction is defined as the selective dismantlement of each building component without causing loss to their mechanical and physical properties. for recycling and reuse (Carruthers, 2013). Deconstruction has also been defined as “construction in reverse” where all building components are dismantled for reuse or recycling purpose (Carruthers, 2013). Whereas demolition of a building means clearing of building by the most expedient means at the end of their design life leading to loss of salvage value of components. One of the main advantages of deconstruction of these abandoned homes is that the material which is deconstructed can be reused for more sophisticated applications such as in building construction rather than burning as fuel or landfilling. (Wu et al., 2015). The reuse of lumber will lead to the reutilization of its maximum potential of salvage value. One of the ways of reutilizing salvaged wood is using salvaged wood to manufacture products like Cross Laminated Timber (CLT) and Glulam. These products once tested and approved as per the industry standards can be used for desired applications. In this research we will concentrate on manufacturing Glulam products by using salvaged lumber from abandoned houses of Michigan.

1.2.4 Advantage of using salvaged lumber during unprecedented times

As shown in figure 1.4 lumber prices in the US have grown from around $400/1000 BF in April 2020 to $1278/1000 BF in April 2021 amid COVID-19 pandemic. The. The high prices are the result of disruptions in the supply chain and huge boost in home improvement projects when the pandemic forced people to stay home. National Association of Home Builders says wood costs are adding $24,000 to the price of a new house. During such unprecedented times, use of salvaged lumber can prove to be very lucrative. The use of salvaged lumber will not only help in maintaining supply and demand during these unpredictable times but will also control the cost of lumber from surging suddenly. Another major advantage of using the salvaged lumber is that the lumber can be obtained from abandoned houses which act as a readymade storage place for wood at all locations. There is no need to put extra effort into storing these salvaged lumbers during normal times. In a nutshell, salvaged lumber can provide a good cushioning effect for surging lumber prices during such unprecedented times at no extra cost.

Figure 1.4: Graph showing rise in lumber price in the US.
(Source: Trading economics, 2021)

1.2.5 Use of salvaged lumber in the construction industry

Salvaged lumber can be used in construction in many ways for example old wood can be used in making wall panels, kitchen countertops, floors, and decks. One of the major advantages of using salvaged lumber is that the same wood is reused again which results in reducing our dependency on virgin lumber. Salvaged lumber comes with a desirable and unique look that cannot be found in newly sawn wood thus giving a unique look to the structure. Another, benefit of using salvaged lumber in construction is that salvaged lumber has its own story which appeals for the finished project and in return, this increases the market value of the project due to sentimental value attached to the material used in the project. Also, using reclaimed wood certified by the Forest Stewardship Council can help the construction or remodeling project earn LEED points. Thus, the use of salvaged wood in construction not only benefits the project by increasing its unique appearance and value but also helps protecting the environment.

1.3 Glulam

Glulam is manufactured by bonding horizontal layers of dimensional lumber or "lams" using adhesives. The grains of these laminations run parallel to the length direction of the member. Glulam can be used for longer spans as any number of laminations can be joined to produce desired long lengths with the help of adhesives. When compared to the pound by pound, glulam is stronger than steel (APA, 2007). This enables glulam to be used in areas where intermediate supports are restricted and in structures where long spans are desired.

1.3.1 History of Glulam

A series of glulam arches erected in 1934 at the US Department of Agriculture Forest Products Laboratory in Madison, Wisconsin is one of the oldest uses of the glulam in the US (Rammer et al., 2013). Degradation of the glue line was one of the major concerns in earlier days when glulam was exposed to the exterior environment. The advent of water-resistant adhesives in 1942 not only solved the concern of glue line degradation but also boosted the development of the glulam industry. The commercial standard CS 253-63 published by the department of commerce in 1963 was the first US manufacturing standard for glulam. Now, ANSI/APA standard A190.1 is the most recent standard used for providing guidelines for the manufacturing of glulam.

1.3.2 Types of Configurations in Glulam

Glulam is manufactured by bonding dimensional lumber together using adhesives. Maximum tension and compression occur at the top and bottom of the glulam, therefore strongest lams are used at the top and bottom of the beams. Comparatively lower structural quality lams can be used in inner sections of the beams. Generally, glulam beams are manufactured in two configurations, unbalanced and balanced beams (APA, 2017).

1.3.2.1 Unbalanced Beam

An unbalanced beam has higher bending stress on the tension side of the beam than the compression side of the beam (APA, 2008). This unbalance in the bending stress allows us to use lumber more efficiently. Comparatively good quality of lumber is used on the tension side of the beam to counter greater bending stress in the tension zone. Because of these unbalanced stresses in the beam, it becomes very vital to be careful while installation of these beams.

1.3.2.2 Balanced Beam

In these beams, the bending stress is distributed uniformly from the horizontal centerline. Balanced beams can be used as a cantilever or continuous beams where the top or the bottom of the beam is highly stressed in tension due to service load. Balanced beams are less cost-efficient than unbalanced beam.

1.4 Research Goal and Objectives

The goal of this study is to characterize the suitability for salvaged lumber to be used as a feedstock for glulam and determine the physical and mechanical properties of such manufactured products against industry reference standards, such as ANSI/APA.

This research aims to find the answer to the following question: "Does the percentage of salvage lumber significantly influence the MOR, MOE, and Maximum flexural strength of glulam?"

There are three main objectives of this research:

- To characterize the residual mechanical and physical properties of salvaged lumber of deconstructed homes of Michigan.
- To manufacture glulam panels (GSL-Glu-laminated Salvaged Lumber) using a mixture of salvaged lumber and virgin lumber; and
- To analyze mechanical properties of Glulam panels manufactured with varying proportions of salvaged lumber.
    a) To test manufactured samples on Instron and to tabulate MOR, MOE and MFL.
    b) To compare 60% and 40% salvaged lumber glulam panels with the control samples.
    c) To find out reduction in MOR, MOE, and MFL percentages when compared to control samples and demonstrate potential for salvaged lumber as a feedstock for glulam

1.5 Scope and limitations of the research

The scope of this research is to characterize the suitability for salvaged lumber to be used as a feedstock for glulam and determine the physical and mechanical properties of such manufactured products against industry reference standards, such as ANSI/APA.

Following are the limitations of this research:

- Limited availability of salvaged lumber is one of the main limitations of this research. To overcome this limitation each of 68 full length samples was divided into 6 sub samples to increase the sample size.
- Access to the lab was hampered due to Covid-19 pandemic. The research lab was inaccessible for 3 months due to surge in Covid-19 cases in Michigan.
- Any movement in cable connecting the blue box and the load cell of Metriguard 340-E changed the MOE reading of the sample, thus hampering the accuracy of the MOE values and grade of the samples. To overcome this limitation, several tested samples were tested again to cross check the MOE value and grade of the sample.
- All samples were not graded on Metriguard 340-E because they failed to clear the minimum requirement of length and thickness of the samples.
- Frequency was induced to the samples by manual tamping which creates room for human error.
- The MOE values obtained from Instron, and MOE values obtained from Metriguard 340-E had a mean difference of 0.54 Mpsi.

1.6 Chapter Summary

This chapter presents the overview of history and rising popularity of the reuse of salvaged lumber due to exponential growth in sustainable building practices. There is great need of reusing salvaged lumber because of limited landfill areas and surplus wood waste supply in the US. Composite members like glulam can be manufacture as per industry standards to meet the growing demands of lumber and to reuse the surplus supply of waste wood in the US. Three main objectives of this research are (i) To characterize the residual mechanical and physical properties of salvaged lumber of deconstructed homes of Michigan. (ii) To manufacture glulam panels (GSL-Glu-laminated Salvaged Lumber) using a mixture of salvaged lumber and virgin lumber; and (iii) To analyze mechanical properties of Glulam panels manufactured with varying proportions of salvaged lumber with ANSI/APA standards (ANSI A190.1-2017).

CHAPTER TWO
LITERATURE REVIEW

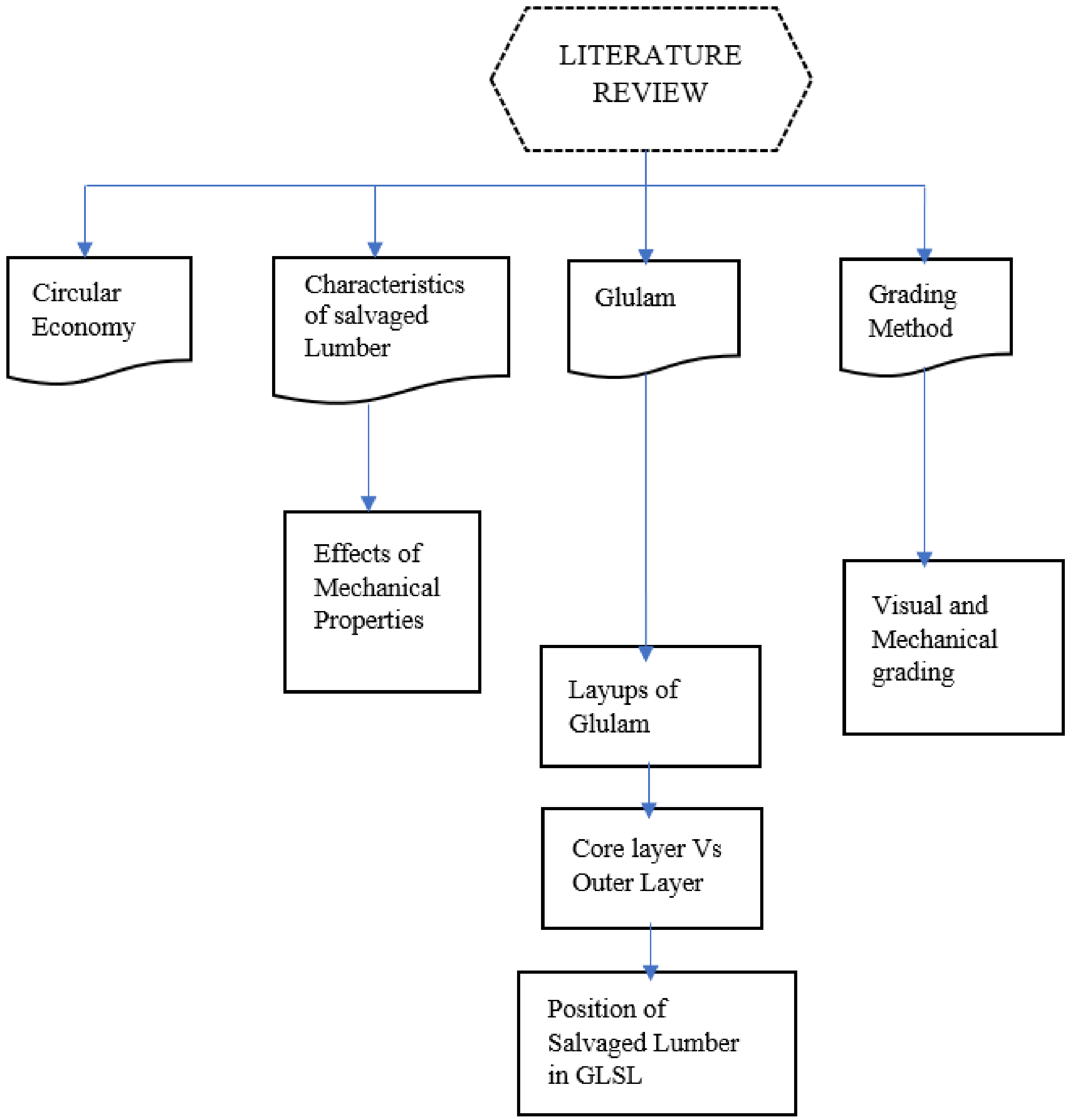


Figure 2.1: Outline of literature review

2.1 Circular Economy

CE is a new model of economic development that tries to 'replace the "end of life" concept by maximizing recycling and reuse of goods and materials to reduce waste generation to the maximum possible extent (Franco-García, 2019). This concept is based on 3 Rs principles Which are reduction, reuse, and recycling. The main objective of CE is to redefine the complete chain of manufacturing, consuming, distributing, and recovery of energy from materials according to the cradle-to-cradle system (Ghisellini, 2018) This system relies on cascading use of renewable resources such as wood. Material like wood is planned for its multiple reuses under this system which ultimately benefits both economically and environmentally. CE also helps in fostering energy saving and reducing GHG emissions (Ghisellini, 2018). CE is a change in mindset which focuses on waste as a potentially useful resource and not as a problem to deal with and dispose of in landfills. In the case of wood, reuse may be the better option when compared with its recycling. An investment of 234% is required in the conventional recycling process of wood (Brown and Buranakarn, 2003). Thus, pushing the recycling benefit ratio below 1 and ultimately making recycling of wood non-profitable. Reuse is considered as the best option because of a larger increase in net carbon storage due to carbon storage in-use products (USEPA, 2012; Diya mantoglu and Fortuna, 2015). Therefore, this research concentrates on the reuse of salvaged wood from abandoned houses of Michigan rather than its recycling.

2.2 Characteristics of salvaged wood

It is very important to study the characteristics of salvaged wood before it can be used to manufacture composite members like Glulam. The salvaged wood has its own past life like the story wood explains even when used in a new product. Wood goes through some changes in its first productive life, but all changes are not harmful. For example, salvaged wood has which has sat in a building or structure for a very long period is likely to have lower moisture content than the freshly sawn wood because it is dried for many years. This change in the salvaged wood makes the wood more durable and adds value to the wood in long run (All-Recycling-Facts, 2014). Salvaged wood from houses is more likely to be stable in dimensions than freshly sawn wood as it has sat under load for many years and has already gone under all changes (Hasek, 2014). Salvaged wood has lesser amount of atmospheric CO2 than freshly cut wood. The reuse of wood will help in decreasing carbon emission as well.

Between the mid-1800s to 1900s, the industrial revolution led to the logging of most of the old-growth forests in the upper Midwest of the US (Quinlan, 2013). These old-growth trees in the upper Midwest of US forests ranged from 100-500 years old (Quinlan, 2013).

If the wood is not subjected to unfavorable conditions the wood not only stays stable but old-growth wood becomes more rot resistant and structurally stable than fresh lumber (Wisconsin Historical Society). As the tree gets older it becomes stronger and its growth rings become tighter (Wisconsin Historical Society). Michigan was one of the top producers from 1840 – 1900 and cradle for industry (Quinlan, 2013). Till 1930 most of the old-growth forests were logged out in the upper Midwest (Quinlan, 2013). There are high chances that these trees which were used from the 1840-1930s will be more stable and must have retained its properties till now. To know the properties of these old wood before use, we can use the “standard grade specifications for yard lumber” of 1923. Circular 296 of the department of agriculture for structural timber and circular 295 which dealt with basic grading rules and working stress for structural timber to know the properties of these old timbers as a benchmark to compare them with the existing stress carrying capacity. The difference between the minimum strength of timber mentioned in standards and existing strength of these old, salvaged materials will give us the strength lost due to aging or unfavorable conditions and loading.

2.3 Effects of aging on Mechanical properties of salvaged wood

The effect of aging on the mechanical properties of wood is of prime importance to maximize the reuse of salvaged lumber. It is important to note that mechanical properties of wood such as modulus of elasticity (MOE) and modulus of rupture (MOR are vital for reuse of salvaged lumber but are not directly related to aging of wood alone. They are also dependent on various factors such as an unknown history of tested wood, lack of standardized testing, and exposure of wood to different environmental conditions. Kranitz (2014) argued that the effect of loading history of wood is related to the age of wood, but it is not a result of the age of wood itself. In the same way, mechanical properties of damaged lumber are significantly reduced; while such reduction is not solely related to aging, but possibly due to state of conservation.

After testing salvaged lumber many researchers concluded that the MOE of wood did not change much over the life cycle of wood. The researchers who reported change in MOE in salvaged lumber had different criteria for wood selection, testing, and analysis of the results. Hirashima (2005), in interesting research reported a decrease in Ultimate tensile strength and MOE of aged keyaki wood by 16.4 and 20.3%, respectively, compared to new wood and later found no significant difference in Ultimate tensile strength or MOE between Akamatsu wood aged 115 years and new wood. Nevertheless, the density of the new timber tested was different than the density of the old timber. Hence, it is difficult to determine if the difference in MOE values were solely due to aging of wood and not because of the difference in the density of the species or the environmental condition to which the primary wood was exposed too.

Rammer (1999), in ambitious research, concluded that both MOR and tensile strength of wood is affected by splits and checks in addition to the aging of lumber. Similarly, Chini et al. (2001) tested old southern pine structural members obtained from different buildings designed for different loading conditions. The average MOR of salvaged timber was approximately 10% lower than new timber. MOR in these experiments was affected by the defects and exposure of wood to different conditions rather than its age.

2.4 Glue-laminated timber

Glue-laminated timber (glulam) was first used in Europe in the early 1890s (Glulam Product Guide, 2017). A series of glulam arches erected in 1934 at the US Department of Agriculture Forest Products Laboratory in Madison, Wisconsin is one of the oldest uses of the glulam in the US (Rammer et al., 2013). Glulam is a composite member manufactured by bonding horizontal layers of dimensional lumber or “lams” using adhesives (Glulam Product Guide, 2017). The grains of these laminations run parallel to the length direction of the member (ANSI A190.1, 2017). Glulam can be used for longer spans as any number of laminations can be joined to produce desired lengths with the help of adhesives. Adhesives used for glulam are required to meet ASTM D2559 and ANSI405 for exterior use and ASTM D7247 for heat durability. Mixing, spreading, assembly temperature, press time and adhesive curing time should be by adhesive manufacturer (ANSI A190.1, 2017). Glulam also has a greater strength-to-weight ratio than steel (AICT 117, 2010; APA, 2008). This enables glulam to be used in areas where intermediate supports are restricted and in structures where long spans are desired giving more flexibility to the designers during designing structures of longer spans. Glulam can offer superior structural performance. Its superior performance is combined with durability for long term. One of the main advantages of glulam is that glulam has a high degree of engineering efficiency. Figure 2.4 shows glulam's engineering efficiency when compared to Mechanically Graded Lumber (MSR) and visually graded lumber.

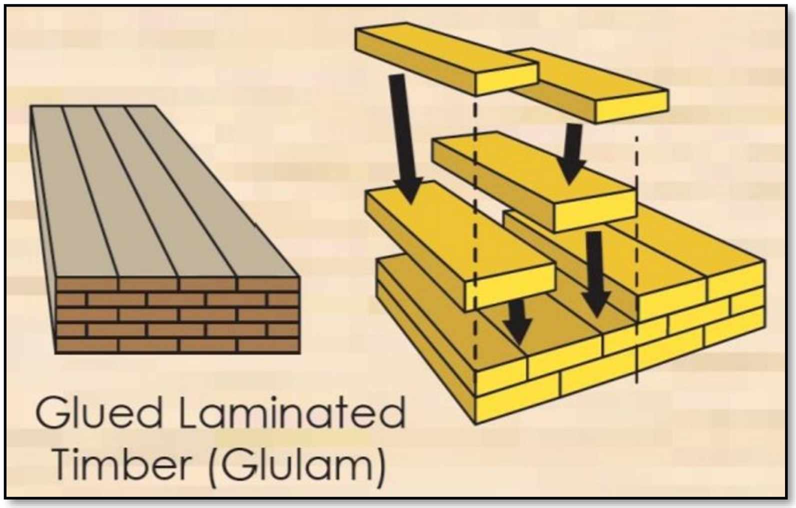


Figure 2.2: Glued Laminated Timber (Glulam)
(Source: Verma, 2018)

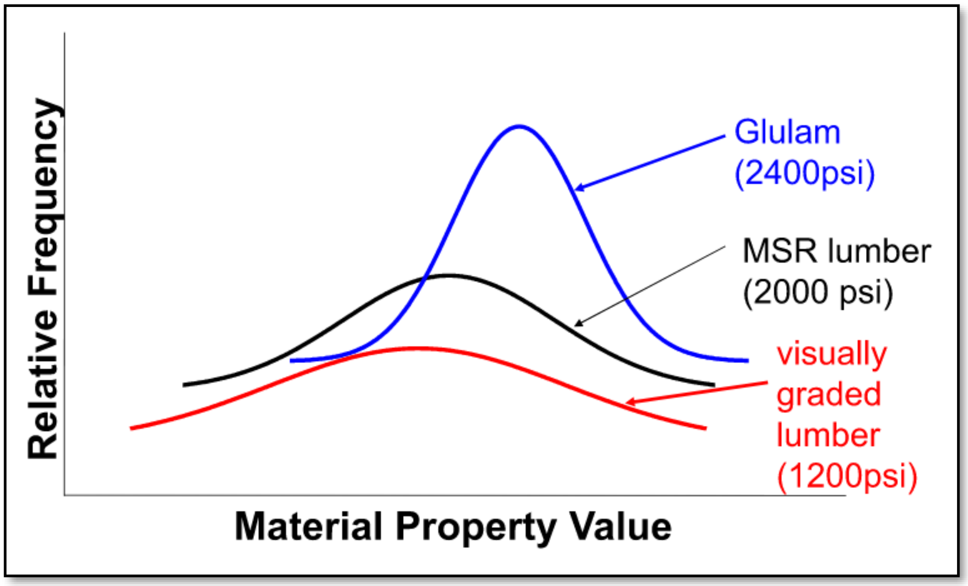


Figure 2.3: Comparison of glulam's engineering efficiency with Mechanically Graded Lumber (MSR) and visually graded lumber.
(Source: The wood products council, 2010)

Uses of Glulam

Glulam has several advantages over other construction materials like concrete and steel. When compared to concrete and steel glulam uses less energy for its manufacturing. It can be used in structures that require longer spans without intermediate supports. Glulam is comparatively lighter than steel and concrete which means it will require less joints and connections and will be easier to handle. It has versatile application and uses as it can be used in beams, columns stairs, and in aesthetical use such as cladding. Treated glulam are dimensionally stable, so this treated glulam can be used in structures with specific climatic demands in harsh weather. It also performs very well against deformation and tension caused by moisture. The carbonized layer around the glulam decreases the oxygen consumption and retards the combustion which makes it safer than steel in fire. All these advantages of glulam over other construction materials used in construction give glulam an edge over other material and prove that glulam can be used vastly used as an excellent alternative construction material.

2.4.1 Types of Configurations in Glulam

Glulam is manufactured by bonding dimensional lumber together using adhesives. Maximum compression and tension occur at the top and bottom of the glulam, respectively, therefore strongest lumber is used at the outermost lams for glulam beams (ANSI A190.1, 2017). Comparatively lower structural quality lams can be used in the inner sections of the beams. Generally, glulam beams are manufactured in two configurations, unbalanced and balanced (APA, 2017).

2.4.2 Unbalanced Layup

An unbalanced layup has higher bending stress on the tension side of the beam than the compression side of the beam (APA, 2017). The unbalanced layup has unequal capacity in positive and negative bending. This layup is mainly for designing simple beams or short cantilever beams. The unbalanced layup requires 5% tension lams on the bottom of the beams (ANSI A190.1, 2020). This imbalance in the bending stress allows us to use lumber more efficiently. Comparatively good quality lumber is used on the tension side of the beam to counter greater bending stress in the tension zone. Because of these unbalanced stresses in the beam, it becomes very vital to be careful while installation of these beams. Therefore, unbalanced beams are marked with "TOP" on the top side of the beam.

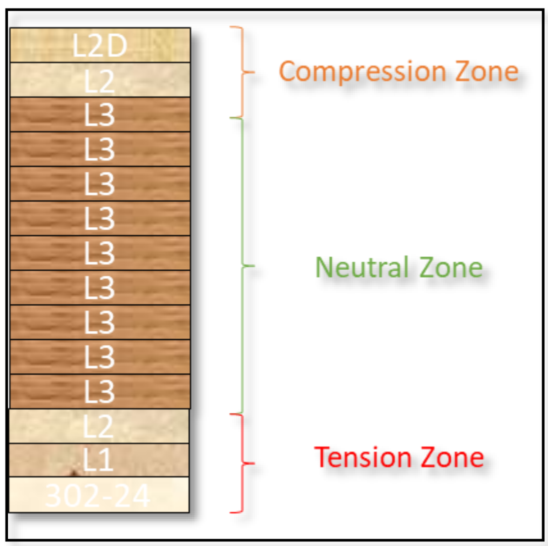


Figure 2.4: Unbalanced layup

2.4.3 Balanced Layup

In this type of layup, the bending stress is distributed uniformly from the horizontal centerline (APA, 2017). Balanced layup has equal capacity in both positive and negative bending. Balanced beams can be used as cantilever or continuous beams where the top or the bottom of the beam is highly stressed in tension due to service load. This layup requires 5% tension lams on the top and bottom of the beams. Balanced beams are less cost-efficient than the unbalanced beam. A balanced layup has equal capacity in both positive and negative bending (APA, 2017).

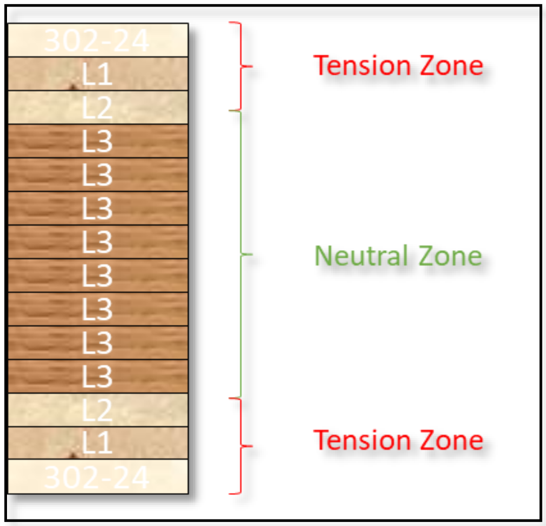


Figure 2.5: Balanced layup

2.4.4 Arrangement of Lumber in Glulam

The arrangements of lumber in Glulam are crucial because of variations in stress distribution in top, bottom, and core layers. The arrangement of laminae by stiffness during the manufacturing process is advantageous (Koch, 1964). It not only makes the beam stiffer but also increases the strength of the beam. Stiffer and stronger laminae are placed on the outer edges where maximum tension and compression stresses occur. The stiffness of the outer laminae plays an important role in determining the overall strength of the beam (Moody, 1970). The comparison of the strength of the beams with laminae arranged by stiffness, appearance, and the random selection concluded that the beams with arranged laminae by stiffness not only increased the average strength but also decreased the variability between beams (Koch and Bohannan, 1965). Therefore, in this study, it is important to keep salvaged lumber in core layers and virgin lumbers in outermost layers where tension and compression stress are maximum.

2.5 Lumber Grading

The mechanical properties of wood vary significantly regardless of species and size. Sometimes strength of lumber of the same size and species may even differ by several hundred percent. The wood used in glulam is either visually or mechanically graded. Visual inspections are carried out to assess the physical characteristics of wood to grade without the use of machines. Many growth characteristics that affect the mechanical properties of lumber can be judged visually. (Kretschmann, 2006). Therefore, growth characteristics are used to group the wood in different grades (Kretschmann, 2006). In general, grading is based on defects and physical properties of wood such as knots, splits, density, pitch pockets, and checks and decay.

To use wood economically and to reduce the complexity, wood with similar mechanical properties is grouped in the same grades. This lumber is called mechanically graded lumber. The characterization of wood in various stress grades is a result of engineering design, sorting criteria, and unique grade name. Mainly six design properties are considered while dividing the wood into different grades. These six properties are (a) modulus of elasticity for an edgewise loading orientation, (b) stress in shear parallel to the grain (c) stress in compression parallel to the grain (d) stress in tension parallel to the grain (e) extreme fiber stress in bending, and (f) stress in compression perpendicular to the grain, (AITC 119). ANSI/AITC A190.1 is used as a glulam manufacturing standard. It specifies product qualifications and quality assurance requirements. All glulam standards require positioning of lam by grades. The quality of lumber is a key to controlling glulam member performance. Design values of laminations are kept in accordance with ASTM D3737 which allows designing based on the growth characteristics of lumber such as knots, slope of grain and density. ASTM D3737 has a standard analysis procedure to generate all major design properties. Table B1 from (ANSI-117, 2020) will be used to determine the layup requirement of glulam manufactured using salvaged lumber. There are 6 tension lamination grades, 302-20, 302-22, 302-24, 302-26, 302-26, 302-28, 302-30. General rules as per chapter C6 of (ANSI 117, 2020) are applied for all grades and sizes of lumber graded as tension laminations. Chapter C6.8 will be used as exceptions to provisions in section C6.2, C6.3 and C6.4. Thickness of each lamination should not be more than 2 inches unless gap-filling adhesive is used for the face and edge bonds (ANSI A190.1, 2017). Dimensional tolerances should be as per section 6.3 of ANSI A190.1 standard. Other than mechanical grade of laminations the edge characteristic of lumber is also important. The edge characteristics of laminations should be in accordance with section C5.3.3 of the ANSI 117 standard.

2.6 Chapter Summary

This chapter covers the existing literature of topics related to this research. It talks about circular economy and its objectives. Then it discusses the literature on glulam available in the market and elaborates the balanced and unbalanced layup in glulam. Then it discusses the importance of arrangement of laminations in glulam to identify that the use of salvaged lumber in the core layers and use of virgin lumber in the outer layers is vital. Last section of this chapter discusses the ANSI standards and their specific sections for lumber grading.

CHAPTER 3
METHODS

3.1 Introduction to Methodology

The literature review conducted in chapter 2 provided the necessary foundation for deciding the methodology for this research. To full fill three objectives of this research that is (a) To characterize the residual mechanical and physical properties of salvaged lumber of deconstructed homes of Michigan. (b) To manufacture glulam panels (GSL-Glue-laminated Salvaged Lumber) using a mixture of salvaged lumber and virgin lumber; and (c) To analyze mechanical properties of Glulam panels manufactured with varying proportions of salvaged lumber with ANSI/APA standards (ANSI A190.1-2017); each objective was divided into three corresponding phases. Each phase was then further divided into various tasks. Completion of all tasks in one phase will mark the completion of that phase. Figure 3.1 shows the three phases of the methodology chapter and various tasks that are to be carried out to full fill all three objectives of this research.

3.2 Phase 1: Characterization of salvaged lumber

Phase 1 is designed to full fill objective 1 of this research. Phase one is further divided into three sub-phases that is phase 1a, phase 1b (part 1), and phase 1b (part 2). In phase 1a, previous works related to the reuse of salvaged lumber or mechanical and physical characteristics of salvaged lumber is studied. Various literature available on related research helped in identifying various crucial variables of interest (VOI) for this study. VOI during sample collection and VOI during lab testing of collected samples were finalized. Also, all samples and their sub-samples were given specific codes so that wood samples tested for these all variables can be marked with the respective codes to identify the samples at the later stage of the research. Table 3.1 shows all the VOI.

The next task after the finalization of VOI and sample codes is to finalize the factors of interest (FOI). Three most important factors were finalized by studying available literature. These three factors were: (1) grades of salvaged lumber, (2) position and percentage of salvaged lumber, and (3) type of adhesives used for binding panels. Each factor was further divided into levels. Factor one had only one level of grade of lumber. Grading of lumber was done in two ways, mechanical grading and visual grading. Mechanical grading of salvaged lumber was decided based on Modulus of elasticity (MOE) and Modulus of rupture (MOR) of salvaged lumber. These two parameters were selected based on ANSI/APA standard Glulam guide. Visual grading of salvaged lumber was also carried out based on the shorthand grading guide of southern pine inspection bureau (SPIB).

Variables to be measured for salvaged wood	Variables to be measured for salvaged wood during sample collection	Sample number
		Location of salvaged wood
		Approximate duration of loading (in years)
		Type of species
		Grade stamp
		Type of wood
	Variables to be measure for salvaged wood in the lab	Visual grading
		Dimensions of lumber (in feet)
		Weight (in lbs.)
		MOE (in psi)
		Specific gravity
		Frequency (in Hz.)

Table 3.1: Showing variables of interest to be measured for salvaged lumber during sampling and lab testing.

Figure 3.1: Three Phases and all tasks in three phases

Phase 1b consists of collecting samples from abandoned homes of the state of Michigan and then testing these collected samples for the characterization of the salvaged lumber. This phase is further divided into tasks. The first task involves collecting information about abandoned homes in the state of Michigan from the municipal corporation of Michigan. Abandoned home that was scheduled for demolition was identified and the sample was collected based on time, day of demolition, and location of the site as per convenience. 68 southern yellow pine and 192 eastern spruce samples were collected randomly from deconstructed houses in Bay City, Michigan in 2017. Spruce is one of the very common species which are used for manufacturing Glulam. The house was built in the mid-1950s; thus, lumber was loaded for approximately 60 years. The 68 samples were approximately 190” X 11.5” X 1.5” in dimension and 192 samples were of various length ranging 30” to 60” tested for all pre-decided variables of interest. Out of 68 samples 34 samples had grade stamps visible on them. The 68 samples were first visually graded using shorthand grading guide of southern pine inspection bureau (SPIB) as shown in APPENDIX D. Further, they were tested for the mechanical properties on Metrigaurd-340-E as they cleared the minimum sample length criteria for testing on Metrigaurd-340-E. Each sample was subjected to hand tapped vibrations 6 times. Metriguard gave the MOE, specific gravity, and the grade for the samples as shown in the APPENDIX B.

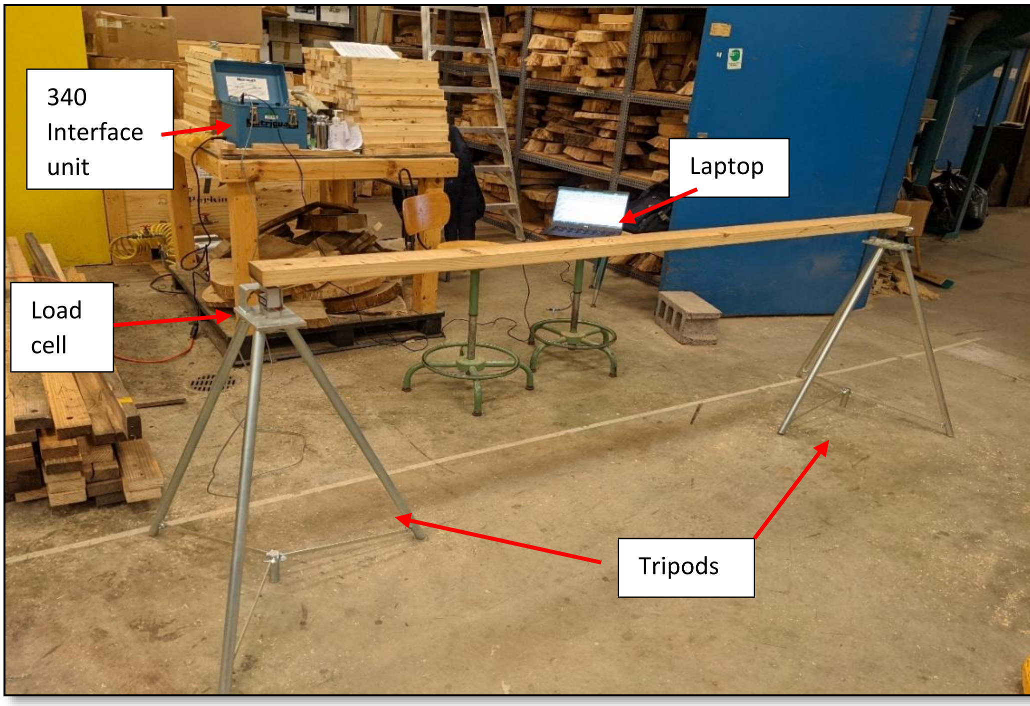
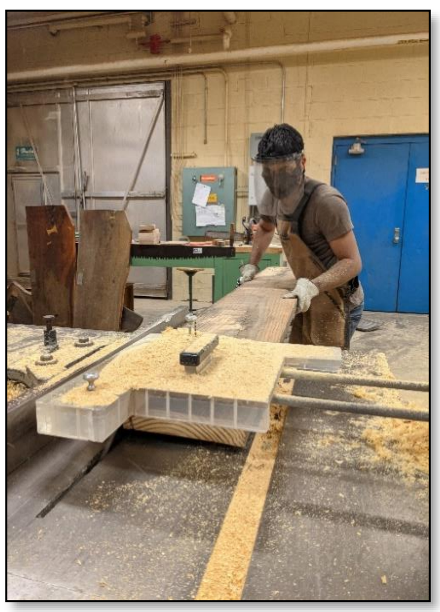


Figure 3.2: Photograph of Metriguard-340-E and its components

Figure 3.3: Photograph of Jointer

(a)Planer

(b) Band Saw



(C) Table Saw

Figure 3.4: Photographs showing various equipments used during making samples for instron

Figure 3.5: Photograph of Instron model 4206 used for testing 3-point bending test

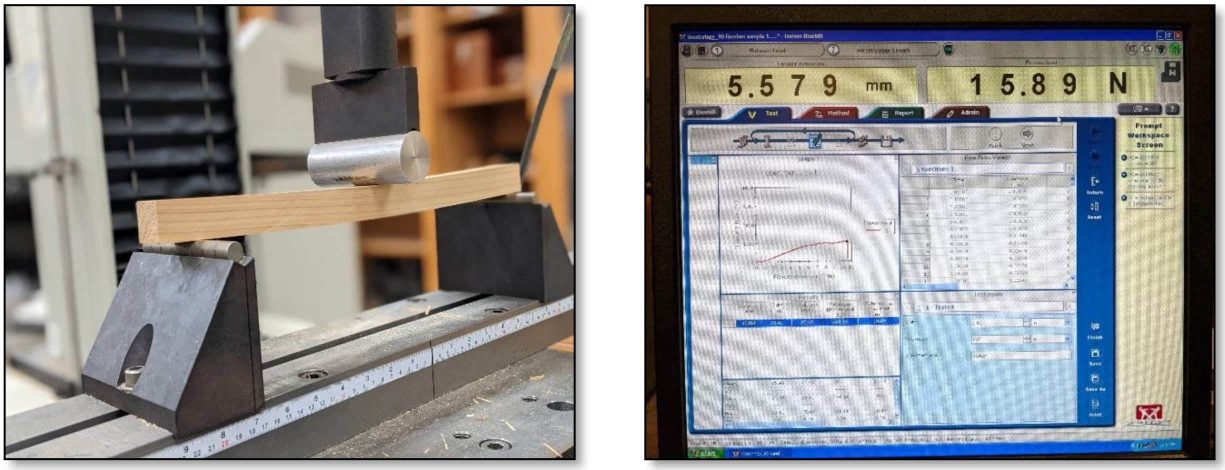


Figure 3.6: (left) Testing of 16”x1”x1” sample on Instron (right) Blue-hill software interface

Phase 1b part 2 consists of checking the effect of physical properties in detail for these 68 samples. Therefore these 68 samples were further cut into 6 smaller pieces as shown in figure 3.7. All sub-samples were marked with unique codes as shown in figure 3.7. These 408 pieces were then again regraded on Metriguard and MOE and specific gravity for all these sub-samples was collected. Thirty random samples were collected from these regraded samples. Random numbers were generated using python language. Then these 30 samples were visually graded. After visual grading, samples were then resurfaced using planer and jointer and 3 sub-samples 16”x1”x1” were made from each 30 samples as shown in figure 3.8. The size of sample was selected as per ASTM D143-14. These 90 samples were subjected to 3-point bending test on Instron-4206. The MOE and MOR values of 90 samples are tabulated in APPENDIX C. The remaining 192 samples were shorter than 70” so they were tested on Instron-4206. All 192 samples were planned and 1 sub-samples of size 16”x1”x1” were made from each main sample. All 192 sub-samples were subjected to 3-point static bending test on Instron at the rate of 1.3mm/min as per ASTM D-143-14 and MOE and MOR values were recorded in the APPENDIX A.

20A(a)	**20B(a)**
20A(b)	**20B(b)**
20A(c)	**20B(c)**

Figure 3.7: Showing 6 sub-samples made from each main sample (sample number 20 in this case) and their nomenclatures for all 68 samples.

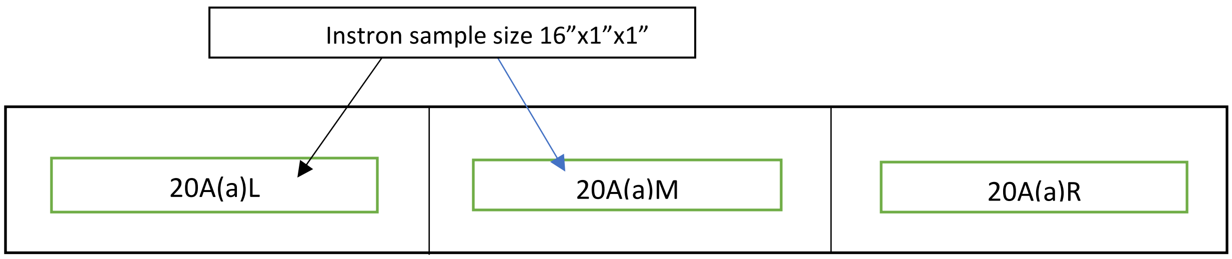


Figure 3.8: Showing the Instron sample cut from each sub-sample (20A(a) in this case) with the nomenclature where L is left, M is middle, and R is right.

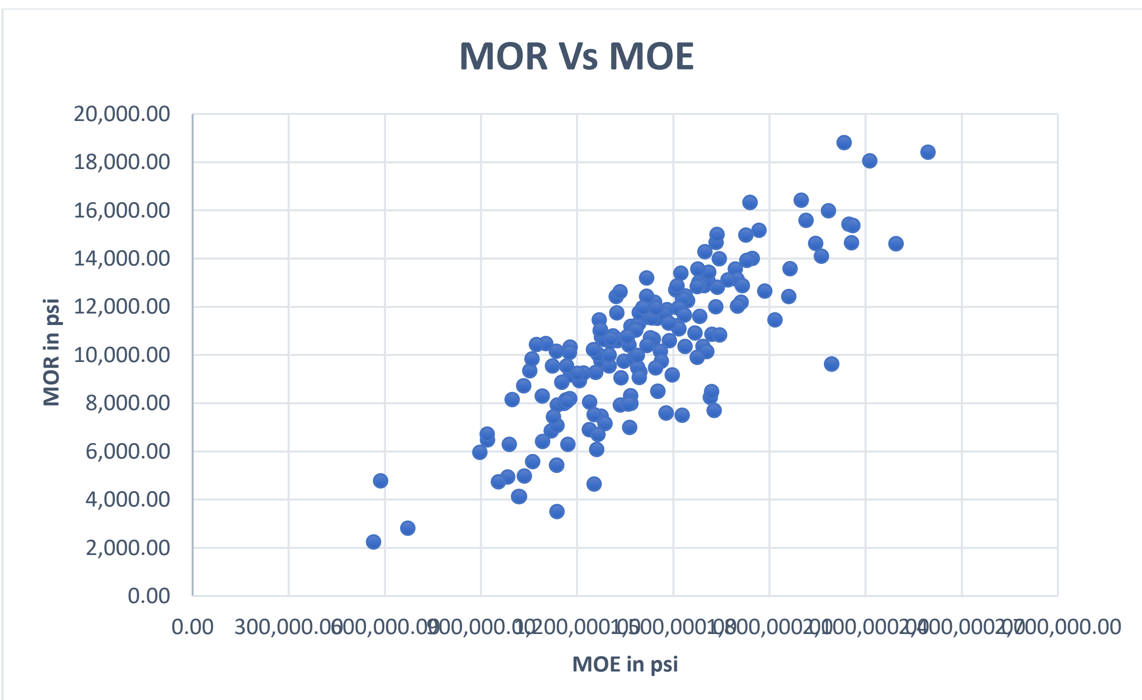


Figure 3.9: Comparison between values of MOR and MOE of 184 Instron samples

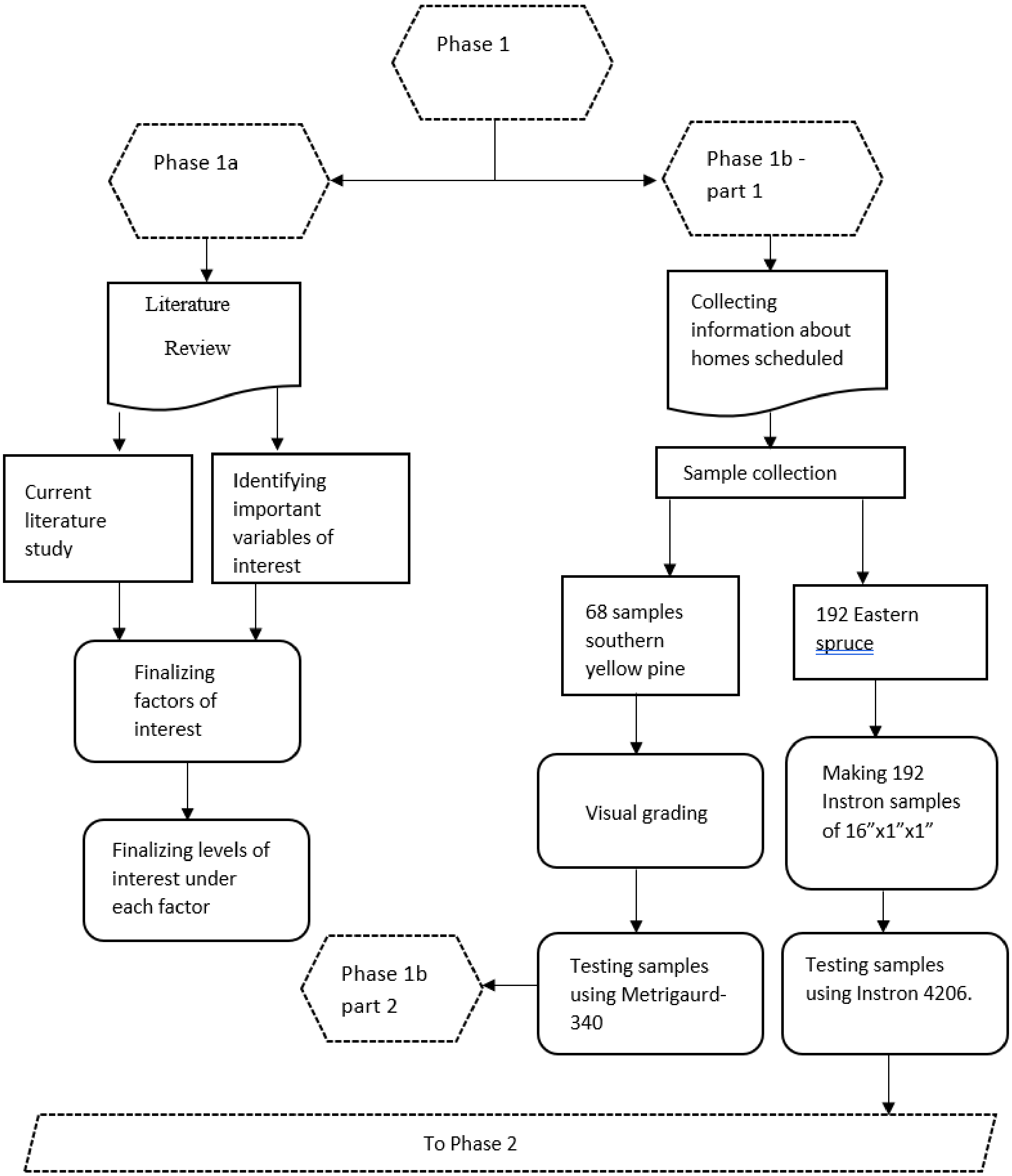


Figure 3.10: Phase 1-This phase consists of two sub phases that is phase 1a for literature review and phase 1b: Characterization of salvaged lumber.

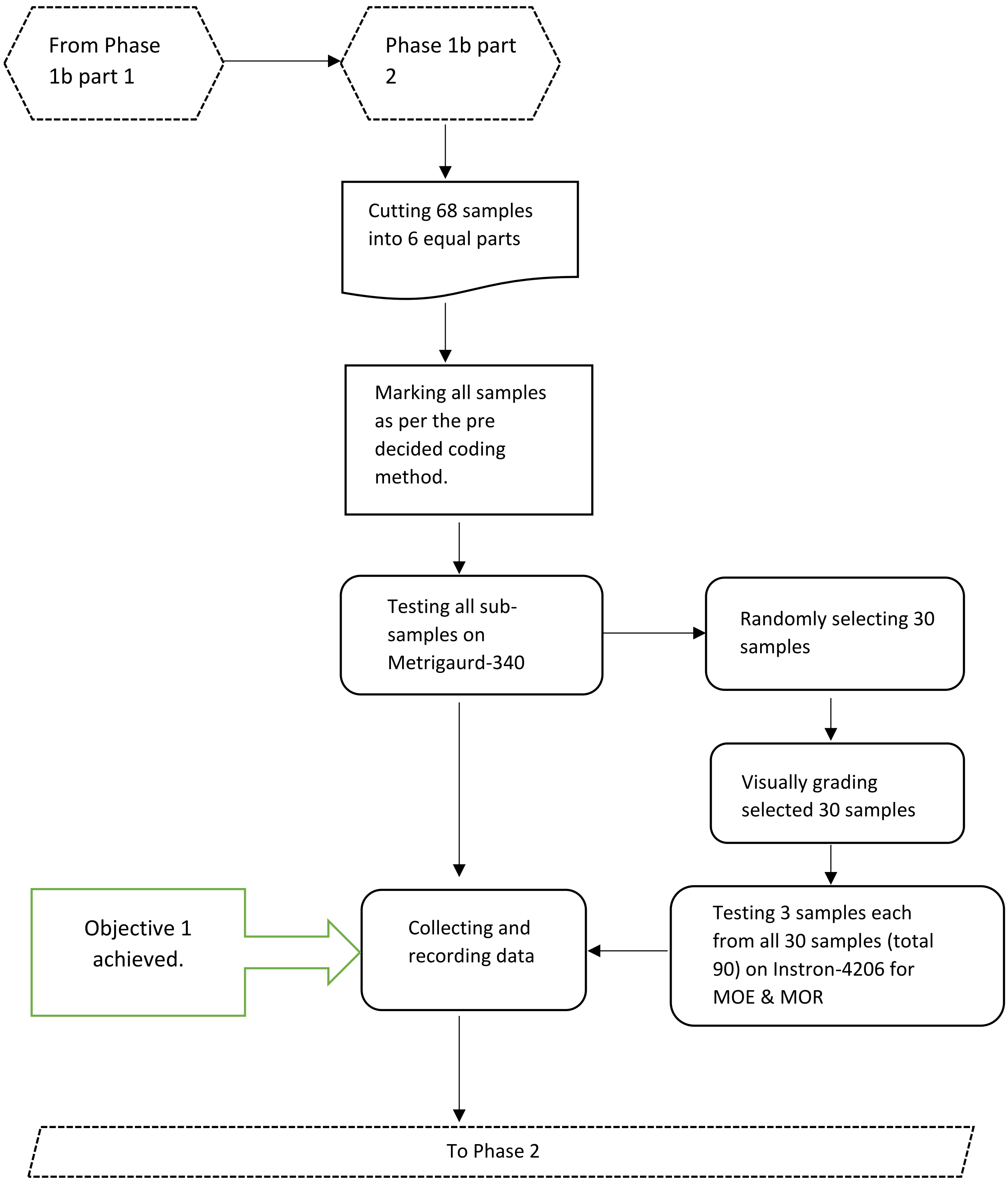


Figure 3.11: Phase 1c- Sample collection and testing

3.3 Phase 2: Manufacturing of GLSL

Phase 2 consists of the manufacturing of composite member, glulam using salvaged lumber (GLSL). 5 layered glulam panels are manufactured using all three factors with their respective levels. Table 3.2 shows the configuration of each sample type and the total number of samples required to be tested in each sample type. A total of 120 samples were manufactured. 30 samples for each type of configuration. 120 samples of five layered glulam were manufactured using salvaged lumber. Each type of sample had 30 replicas to avoid outliers and errors. 60 samples had salvaged lumber in middle three layers (second, third and fifth layer) of glulam (60% salvaged lumber and 40% virgin lumber) as shown in figure 3.12. Other 60 samples had salvaged lumber in the middle layer (20% salvaged lumber and 80% virgin lumber) as shown in figure 3.14. Two adhesives polyurethane and lignin were used for binding five layers of glulam. 60 samples were manufactured using PU based adhesive and 60 samples were made using lignin. All 120 samples were manufactured as per section 3.3 of this thesis. All 120 samples were tested on Instron-4602 for MOE and MOR values. Thirty control samples were manufactured using virgin lumber only, to cross check if the manufacturing method has any major impact on the MOE and MOR values of the samples.

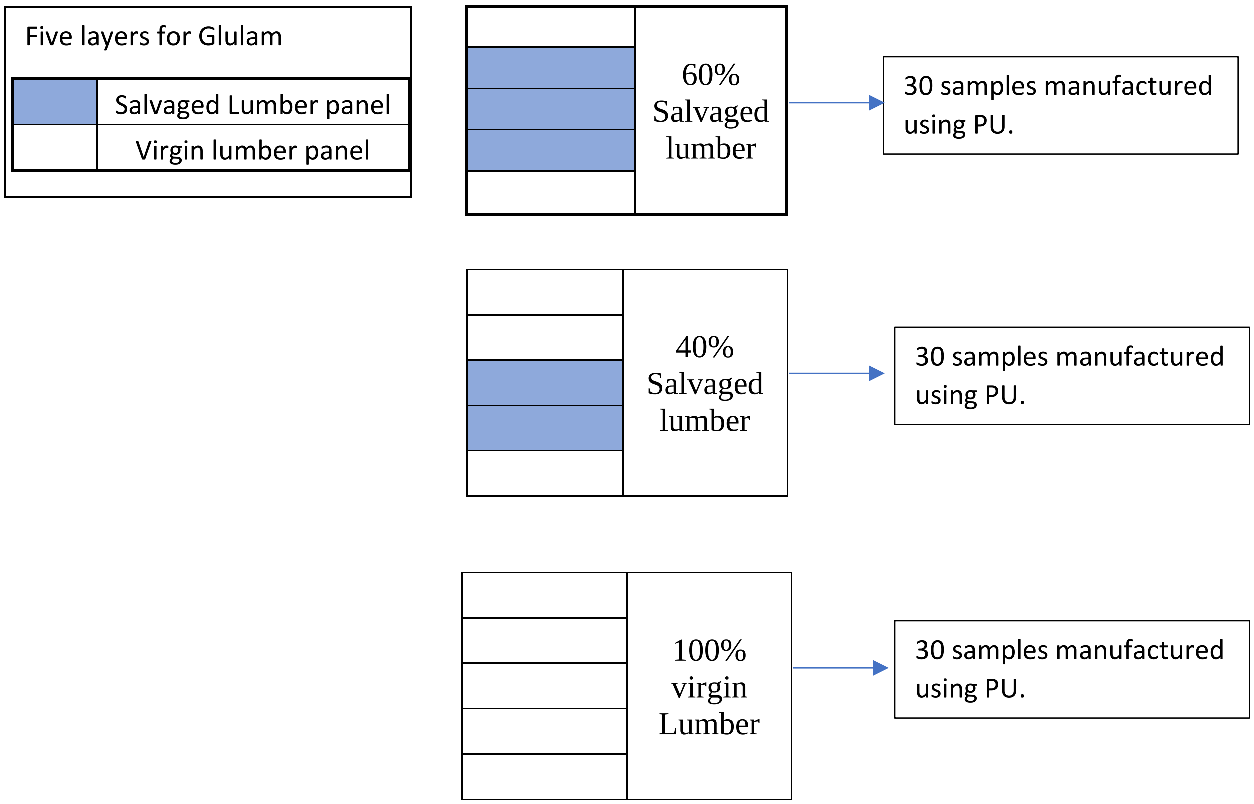


Figure 3.12: Five layered Glulam panels with various percentages of salvaged wood in different positions.

Type of samples	Factor 1	Factor 2			Factor 3	No. of samples
	Grading of lumber	Percentage of salvaged lumber			Type of adhesive	
		40%	60%	0%		
1	4	YES			PU	30
2	4		YES		PU	30
3	4			YES	PU	30
					Total	90

Table 3.2 Sample type and total number of samples

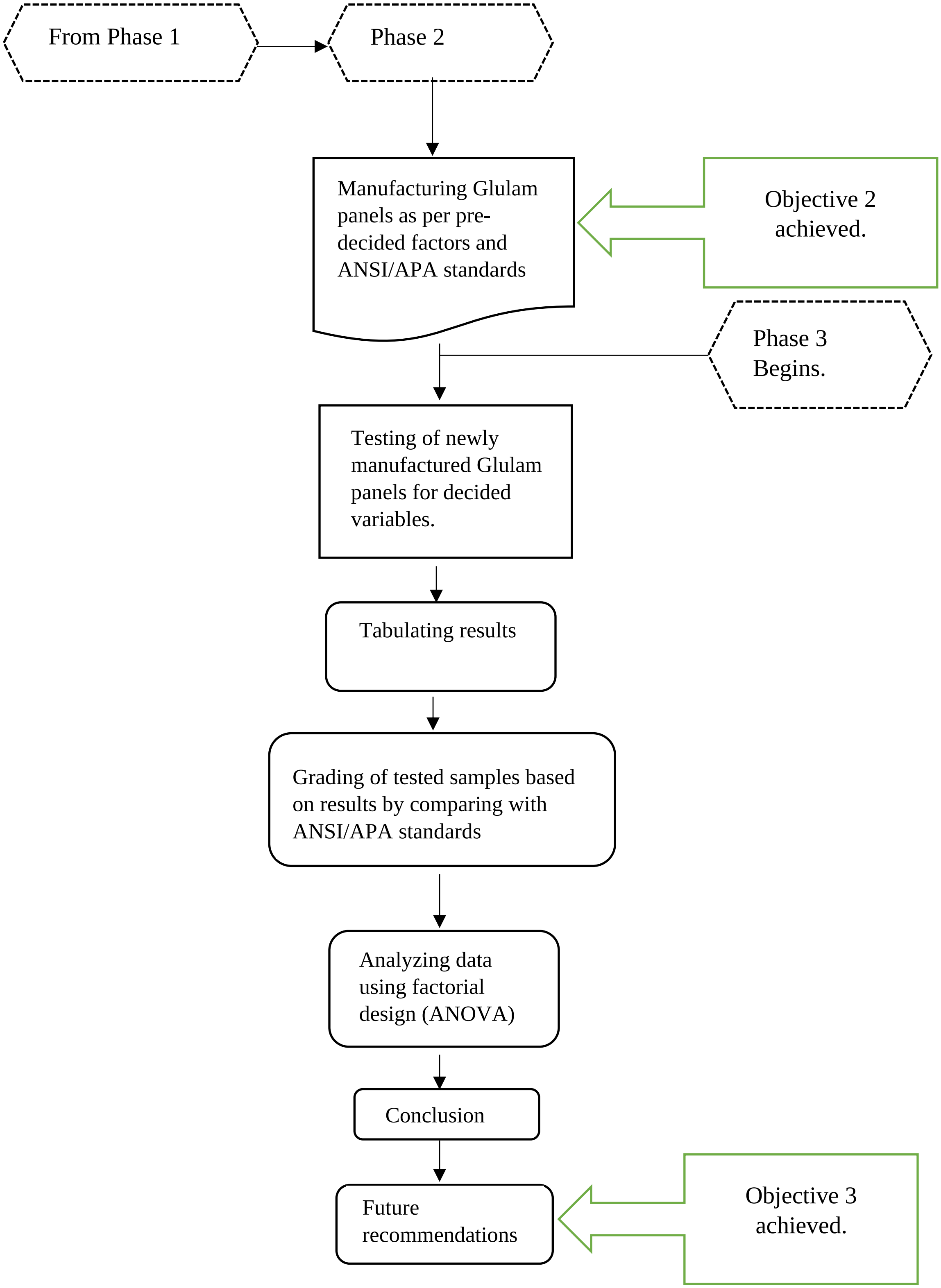


Figure 3.13: Phase 2 Manufacturing, testing, and analyzing the results with future recommendations.

3.4 Performance of Glulam

3.4.1 Manufacturing standards and process

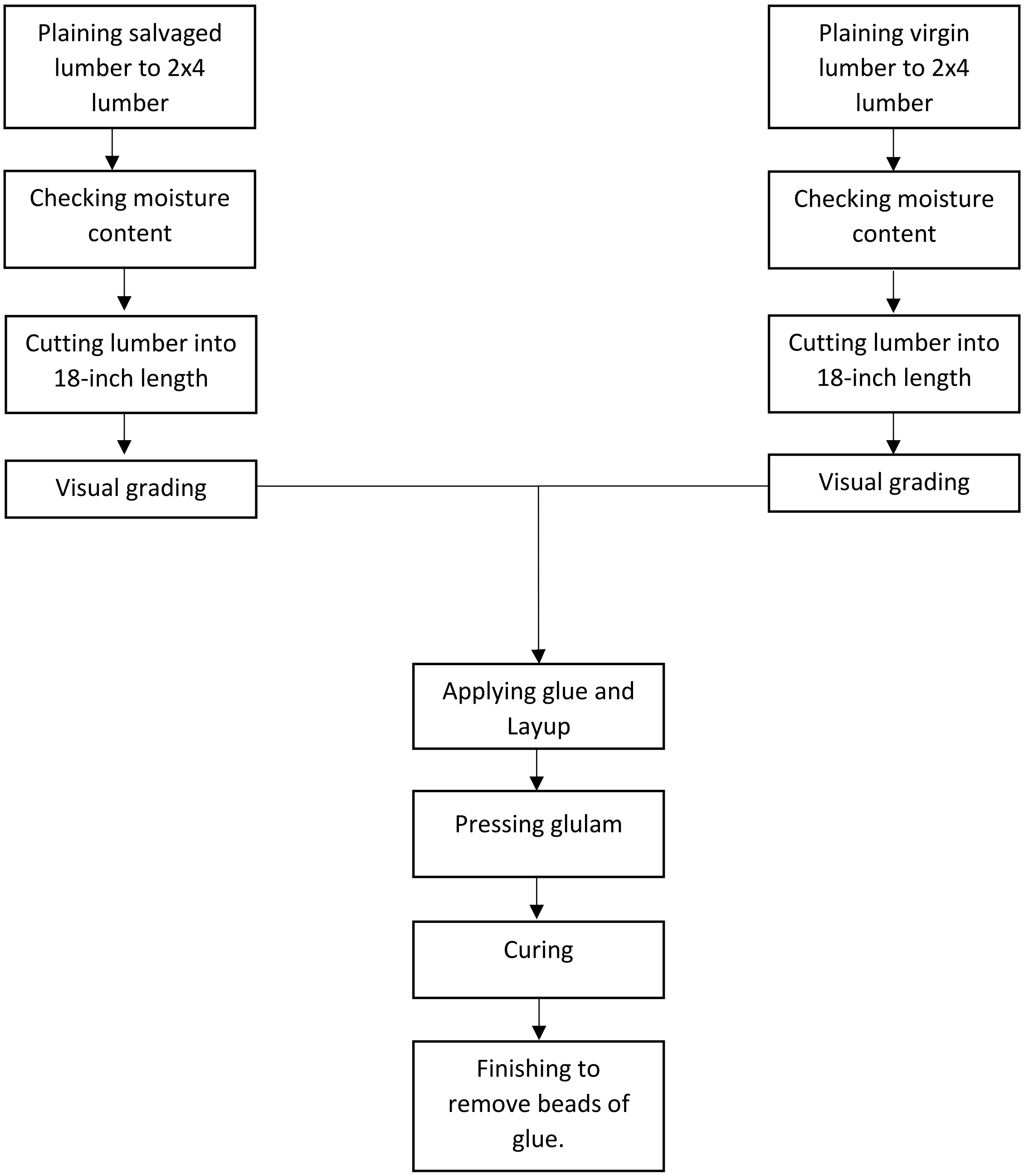


Figure 3.14: Process flow diagram for glulam manufacturing

Glulam was manufactured by gluing salvaged lumber and virgin lumber together to form larger and stronger structural members. The flow chart of the glulam manufacturing process is shown in figure 3.14. Moisture content of salvaged lumber was first measured using a hand-held moisture meter. As the salvaged wood was sitting in a dry environment for about two years its moisture content was below 12%. Therefore, kiln drying was not required for drying salvaged lumber. After checking the moisture content plaining of salvaged lumber was carried out. These lumbers were passed from jointer and planner to get desired (2x4) lumber dimensions. Then these lumbers were cut to 18-inch length using a circular saw. A total of 240 laminations was made and all 240 laminations were visually graded as per ANSI 117 standard for its edge characteristics.

Virgin lumbers were directly obtained from the market. Moisture content was checked and confirmed for each lumber. Then all lumbers were planned to 2x4 lumber by passing them from jointer and planner. The 2x4 lumbers were then cut to 18-inch length using a circular saw. A total of 360 laminations was made and visually graded for their edge characteristics.

After making salvaged lumber laminations and virgin lumber laminations structural glue (polyurethane) was applied on the faces of laminations. The resinated lumber was assembled into three specified lay-up patterns as shown in figure 3.12. Ready samples were then clamped in a clamping bed and pressed by the manual press for 30 mins to bring the lumber into close contact. After 30 mins the glulam samples were removed from the clamping system. The samples were allowed to cure for 24 hours. After curing, beads of resin that squeezed out between the boards were removed before testing.

Combination	4–7 Lams			8 or More Lams		
24F-E/SPF1 (Balanced)	5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6
	15%	2.0E6 SPF	—	10%	1.8E3 SPF	—
	5%	1.8E3 SPF	—	—	—	—
	—	1.4E2 SPF	—	—	1.4E2 SPF	—
	5%	1.8E3 SPF	—	—	—	—
	15%	2.0E6 SPF	—	10%	1.8E3 SPF	—
	5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6
	4–7 Lams			8 or More Lams		
24F-E/SPF3 (Unbalanced)	20%	L2D DF	—	5%	L2D DF	—
	5%	1.8E3 SPF	—	10%	1.8E3 SPF	—
	—	1.4E2 SPF	—	—	1.4E2 SPF	—
	5%	1.8E3 SPF	—	—	—	—
	15%	2.0E6 SPF	—	10%	1.8E3 SPF	—
	5%	302-24 SPF	2.0E6	5%	302-24 SPF	2.0E6

Figure 3.15: Layup requirements for structural glued laminated timber (Southern Pine Fir)
(Source: ANSI 117, 2020)

Variables to be measured for newly manufactured CLT/glulam panel using salvaged lumber	**Code of sample**	The method used to calculate/identify variables
	Sample number	
	Position of salvaged lumber in panel	
	Moisture content	Oven drying method
	Dimensions of lumber (in inches/feet)	
	Density	Metriguard-340
	MOR	
	MOE	
	Specific gravity	

Table 3.3 List of variables to be measured for newly manufactured Glulam panel.

3.5 Phase 3: Mechanical testing of manufactured Glulam panel

Phase 3 Once GLSL samples were manufactured they were tested for all VOI, and results were tabulated. The moisture content of manufactured panels was measured using a moisture meter. All 120 samples were tested on Instron by keeping a 1-inch overhang on both sides as shown in the figure. All 120 sub-samples were subjected to a 3-point static bending test on Instron at the rate of 1.3mm/min as per ASTM D-143-14 and MOE and MOR values were recorded in APPENDIX E.

3.6 Data Analysis

Descriptive statistics are used to analyze the recorded data. Informed by factorial design the one-way ANOVA was used. Hypothesis tests were carried out wherein the classification of data is based on two factors (i) Position of salvaged lumber in GLSL (ii) Type of adhesive used for manufacturing GLSL. It was used to compare levels of the two independent variables involving multiple observations at each level. The one-way ANOVA helps in examining the effect of the two factors on the continuous dependent variable.

3.7 Data Quality Measures

To maintain the accuracy of testing Metrigaurd-340 equipment was calibrated every week. Once Glulam panels are manufactured and tested, some tests will be randomly repeated for already tested samples again to cross-check the accuracy of the tested sample readings. This will not only help in testing the accuracy of the experiments but also help in eliminating false reading during the final analysis of the observations and drawing out the conclusion at the end of the research.

To cross-check the reliability of the manufacturing process, 30 glulam control samples are manufactured with 100% virgin lumber of 1.8 Mpsi were tested on Instron. Also, to check the accuracy of the calibration of Instron, 30 virgin lumber samples of size 16”x1”x1” were tested.

3.8 Chapter Summary

This chapter starts by explaining the method used for achieving all three objectives of the research. The method for fulfilling the first objective of characterization of salvaged lumber is described in Phase 1 part 1 and part 2. The purpose of phase 2 is to achieve the second objective of manufacturing GLSL using salvaged lumber. Phase 3 helps is achieving the third objective It consists of 3 phases and each phase is subdivided into tasks to achieve the third objective of analyzing the data obtained from testing the GLSL. A strong positive correlation between MOE and MOR was observed for the 184 samples tested on Instron. MOE from Metriguard 340-E was found to be lesser by an average of 0.54 Mpsi when compared with MOE from Instron for the same samples. A correlation between visual grading of salvaged lumber and MOE values was found. Finally, two-way ANOVA was used to analyze the 2 x 2 factorial matrix.

CHAPTER 4
RESULTS

4.1 Visual Inspection

Out of 68 samples of salvaged lumber, 27 Samples were visually inspected for Knots, shakes/checks, end splits, the slope of grain, nail holes, and physical damage. Results are tabulated in APPENDIX D. Shorthand grading guide of southern pine inspection bureau was used for visual grading of these 27 samples. All 27 samples had a slope of less than 1:10. 3.7% of total samples were of grade 1, 18.5% of samples were of grade 2, 11.1% were of grades 3, and 29.6% were of grade 4.

2.0E6 SPF	ANSI 117-2020	1.67; edge characteristics < 1/6 of cross-section
1.8E3 SPF	ANSI 117-2020	1.48; edge characteristics < 1/3 of cross-section
1.4E2 SPF	ANSI 117-2020	1.2; edge characteristics < 1/2 of cross-section

Table 4.1: Table showing criteria for visual characteristics and their reference standards

Out of the total of 27 samples, 21 samples were graded out as 2.0 E6 SPF based on MOE values from Merguard. Out of these 21 samples, two samples could not meet the E6 visual requirements. Sample numbers 44 and 58 both graded out as 2.0E6 SPF based on MOE; however, due to the presence of large knots, they could not meet the E6 portion of the grade. So, 19 out of 21 samples passed 2.0E6 SPF grade criteria, both from MOE and visual requirements point of view.

	Number of Samples Passing			
	E Only (n=68)	**E Plus Visual (n=27)**		
Grade	**Number**	**%**	**Number**	**%**
2.0E6 SPF	43	63.2	21	77.7
1.8E3 SPF	55	80.8	27	100
1.4E2 SPF	66	97.0	27	100

Table 4.2: Lamination Grade Results

The MOE and MOR relationship were studied based on the results obtained from testing 408 southern pine samples on Metrigaurd-340E for MOE and then testing 30 randomly selected samples from 408 samples on Instron for MOE and MOR. Figure 3.9 shows a comparison between values of MOR and MOE of 184 Instron samples. The Pearson correlations were run between sample MOR and MOE obtained from these 186 samples. MOR and MOE had a strong positive correlation to each other with r=.811 after ignoring 2 outliers. The value of t- statistics were found to be 18.69 with 184 as the degree of freedom. The p-value of the given data is 4.017 x 10-44 which is less than 0.01. Hence the given data is statistically significant.

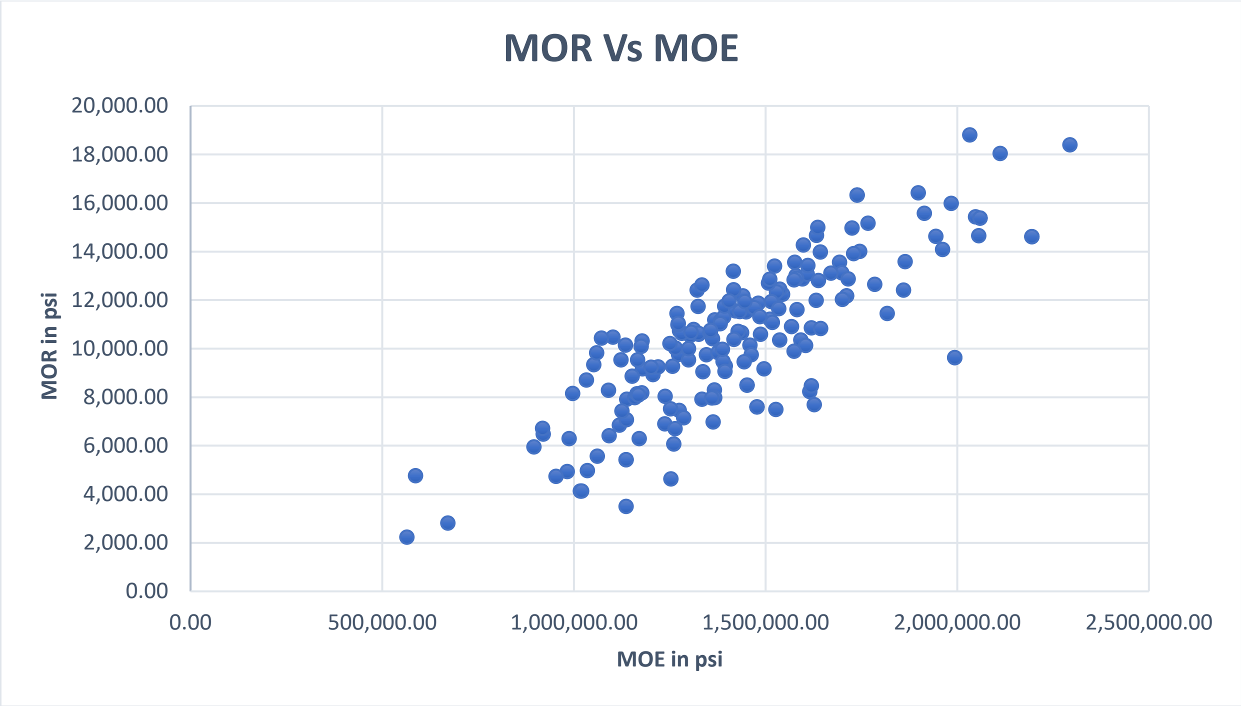


Figure 4.1: Comparison between values of MOR and MOE of 184 Instron samples

Figure 3.11 shows the difference between MOE values from Metriguard 340-E and Instron. MOE values obtained from Instron were higher for 93% of tested samples when compared to MOE values obtained from Metriguard 340-E. Figure 3.10 shows the box plot of the difference between MOE values of Metriguard 340-E and Instron. The box plot showed the median value of .46 Mpsi and the mean value of 0.54 Mpsi.

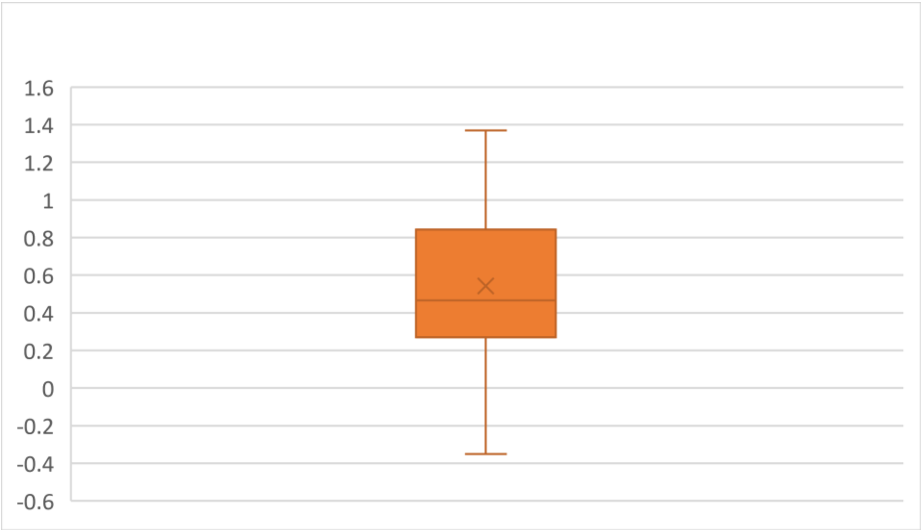


Figure 4.2: Box plot showing the difference between MOE values obtained from Metriguard 340-E and Instron

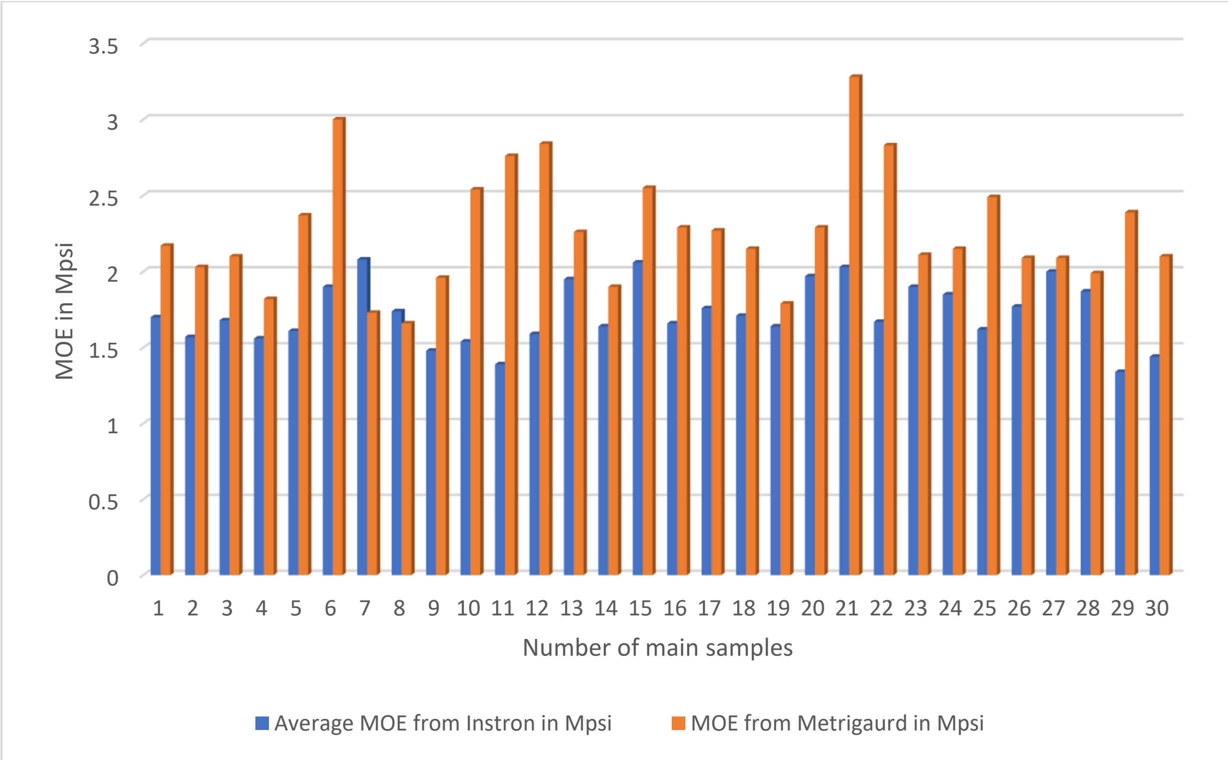


Figure 4.3: Bar graph showing number of samples with the difference between average MOE values obtained from Metriguard 340-E and Instron

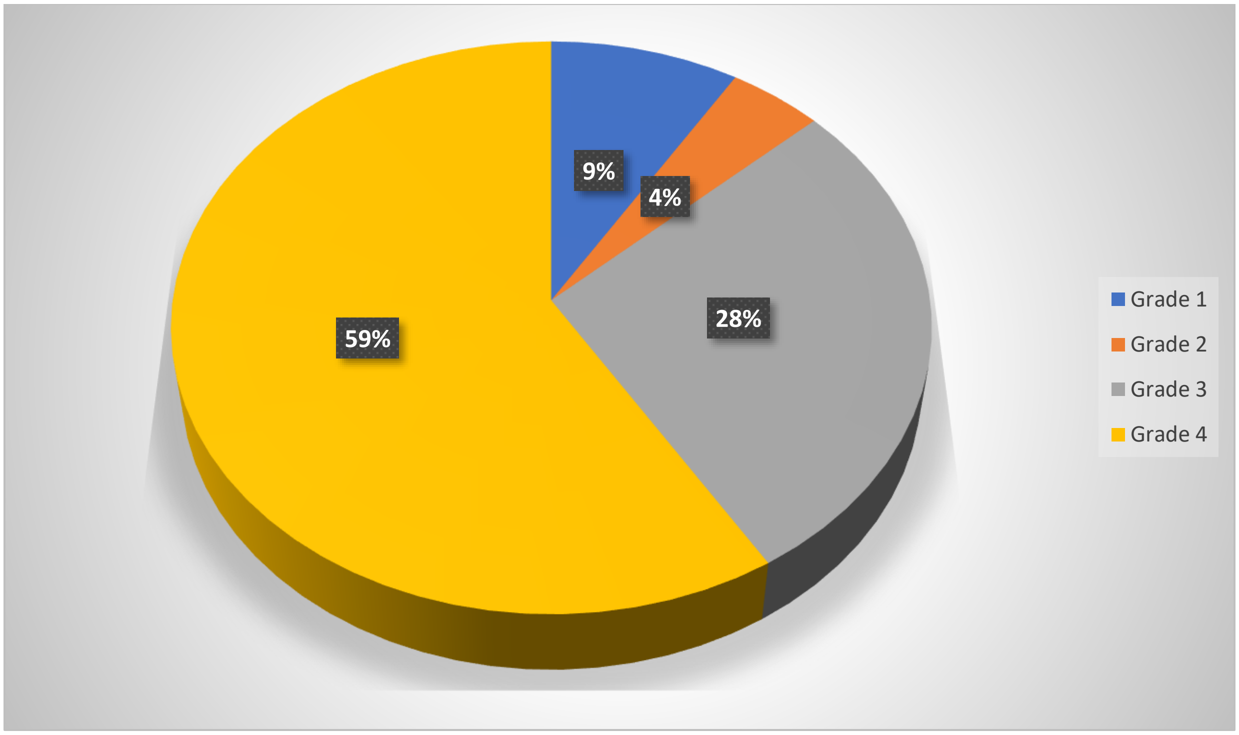


Figure 4.4: Pie chart showing the distribution of grades for 68 samples of salvaged lumber based on MOE values from Metriguard

Out of 68 samples, 43 samples were graded as 2.0E6 SPF based on MOE values obtained from Metrigaurd-340. 55 samples were graded as 1.8E6 SPF and 66 samples were graded as 1.4E6 SPF.

One-way ANOVA was run between 40% of salvaged lumber samples and Control samples, 60% of salvaged lumber samples and Control samples, and 60% of salvaged lumber samples and 40% of salvaged lumber samples for MOE, MOR, and maximum flexural load. SPSS software was used to run one-way ANOVA. The Independent variable is a type of lumber that is salvaged or virgin, the dependent variable is MOE and MOR.

One way Between subjects ANOVA was run with the percentage of salvaged lumber as the independent variable and MOR, MOE, and Maximum flexural strength as the dependent variable.

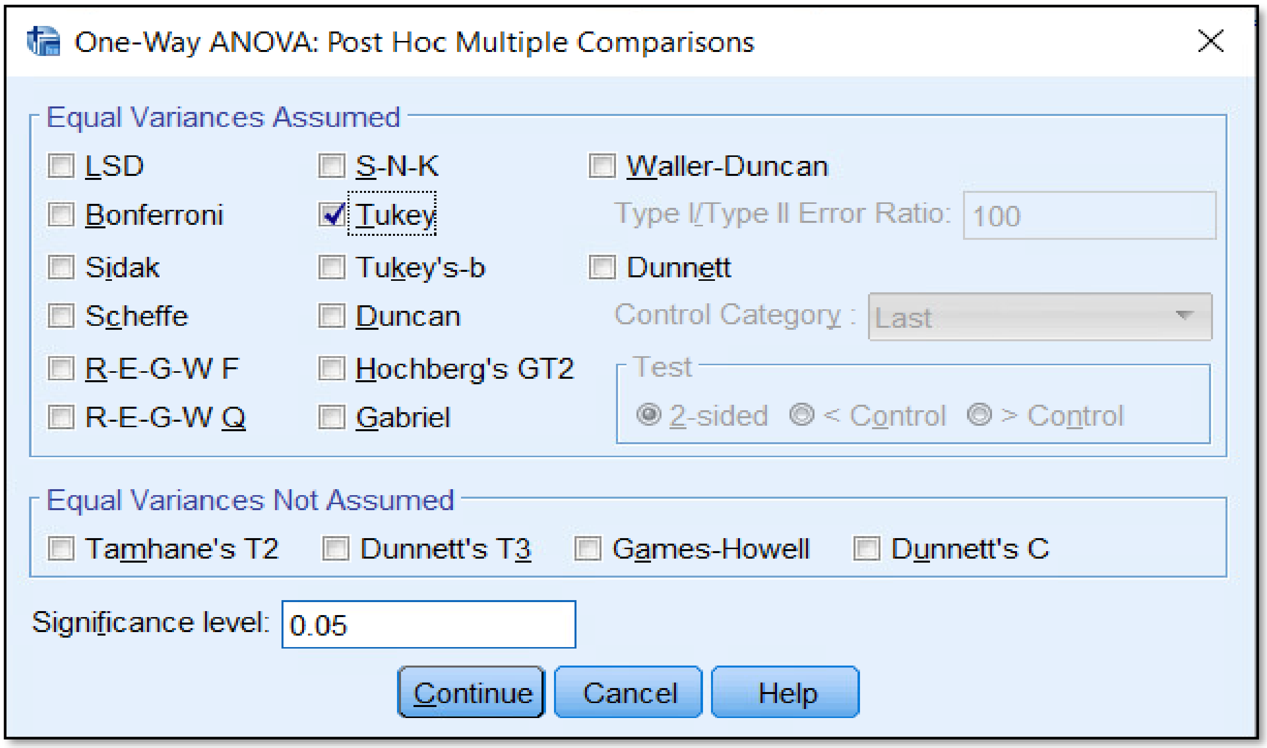


Figure 4.5: Screenshot from SPSS software showing Tukey test selection with 0.05 significance level

A one way Between subjects ANOVA was run with the percentage of salvaged lumber as the independent variable and MOR, MOE, and Maximum flexural strength as the dependent variable.

4.2 Modulus of elasticity

Oneway

Descriptives

MOE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
2V_60%	27	30511.42	12400.481	2386.474	25605.96	35416.89	2466	55242
3V_40%	26	30677.52	10394.870	2038.602	26478.94	34876.10	11863	49105
Control	30	31094.46	15404.807	2812.520	25342.21	36846.71	3486	52556
Total	83	30774.19	12872.035	1412.889	27963.50	33584.88	2466	55242

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
MOE	Based on Mean	4.559	2	80	.013
	Based on Median	2.558	2	80	.084
	Based on Median and with adjusted df	2.558	2	72.252	.084
	Based on trimmed mean	4.434	2	80	.015

ANOVA

MOE

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5184363.608	2	2592181.804	.015	.985
Within Groups	1.358E+10	80	169766718.7		
Total	1.359E+10	82			

Figure 4.6: Descriptive statistics and Test of homogeneity of variance for MOE values of 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

Robust Tests of Equality of Means

MOE

	Statistic[a]	df1	df2	Sig.
Welch	.013	2	53.041	.987
Brown-Forsythe	.016	2	76.127	.984

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MOE

Scheffe

(I) Percentage_salavged	(J) Percentage_salavged	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
2V_60%	3V_40%	-166.099	3580.104	.999	-9095.95	8763.75
	Control	-583.035	3456.378	.986	-9204.28	8038.21
3V_40%	2V_60%	166.099	3580.104	.999	-8763.75	9095.95
	Control	-416.936	3491.186	.993	-9125.00	8291.13
Control	2V_60%	583.035	3456.378	.986	-8038.21	9204.28
	3V_40%	416.936	3491.186	.993	-8291.13	9125.00

Figure 4.7: Tests of equality of means and Post Hoc test for MOE values of 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

Null Hypothesis: There are no significant differences in MOE values across different percentages of salvaged lumber in glulam. Alternate hypothesis: There is significant differences in MOE values across different percentages of salvaged lumber in glulam. This hypothesis tests if the MOE values differ across the three types of layups. As each sample was drawn independently of the other sample, the values of MOE are assumed to be normally distributed. The results showed no significant difference between the percentage of lumber and MOE of glulam. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples ($p=0.999>0.05$) and the Control samples ($p=0.993>0.05$). Also, control samples are not significantly different than 60% of salvaged lumber samples ($p=986>0.05$). The null hypothesis that there is no significant difference in MOE of glulam between the different percentages of salvaged lumber samples would be accepted.

Homogeneous Subsets

MOE

Scheffe[a,b]

Percentage_salavged	N	Subset for alpha = 0.05
		1
2V_60%	27	30511.42
3V_40%	26	30677.52
Control	30	31094.46
Sig.		.986

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 27.565.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

Figure 4.8: Scheffe test for MOE values of 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

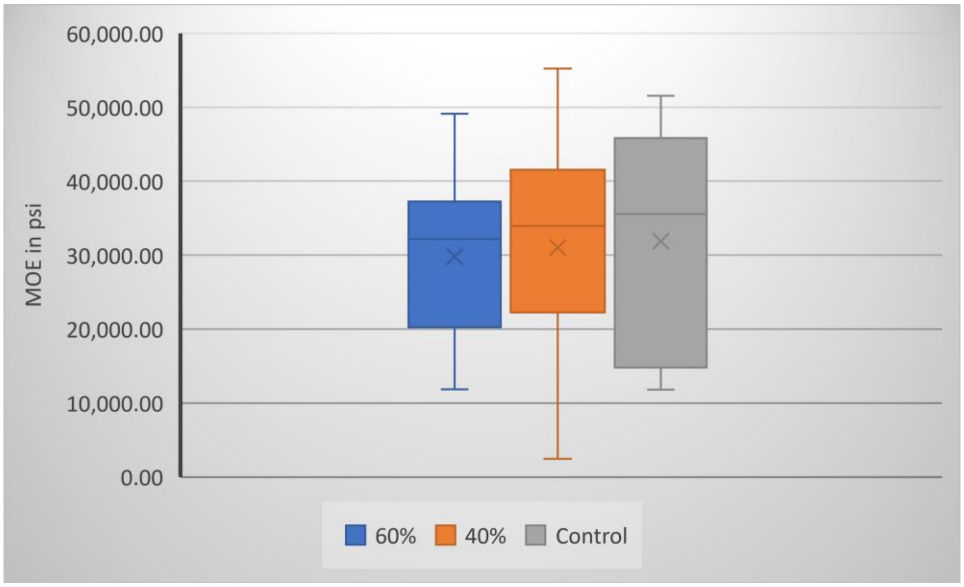


Figure 4.9: Graph of Mean of MOE values on y-axis vs Percentage salvage lumber on the x-axis for 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

Mean MOE for 60% of salvaged lumber samples was around 30500 psi and standard deviation of 10432.91, Mean MOE for 40% of salvaged lumber samples was around 30700 psi and standard deviation of 13260.94, and that of control samples was around 31100 psi and standard deviation of 14494.52.

4.3 Modulus of rupture

Oneway

Descriptives

MOR

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2V_60%	30	2308.86	246.410	44.988	2216.85	2400.87	1889	3015
3V_40%	30	2458.56	492.458	89.910	2274.68	2642.45	1316	3437
Control	30	2579.46	338.025	61.715	2453.24	2705.68	1919	3410
Total	90	2448.96	385.260	40.610	2368.27	2529.65	1316	3437

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
MOR	Based on Mean	4.696	2	87	.012
	Based on Median	3.146	2	87	.048
	Based on Median and with adjusted df	3.146	2	60.825	.050
	Based on trimmed mean	4.734	2	87	.011

ANOVA

MOR

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1102551.828	2	551275.914	3.961	.023
Within Groups	12107326.56	87	139164.673		
Total	13209878.39	89			

Figure 4.10: Descriptive statistics and Test of homogeneity of variance for MOR values of 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

Robust Tests of Equality of Means

MOR

	Statistic[a]	df1	df2	Sig.
Welch	6.365	2	54.319	.003
Brown-Forsythe	3.961	2	66.901	.024

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: MOR

Tukey HSD

(I) Percentage_salvaged	(J) Percentage_salvaged	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
2V_60%	3V_40%	-149.705	96.321	.271	-379.38	79.97
	Control	-270.605*	96.321	.017	-500.28	-40.93
3V_40%	2V_60%	149.705	96.321	.271	-79.97	379.38
	Control	-120.900	96.321	.424	-350.57	108.77
Control	2V_60%	270.605*	96.321	.017	40.93	500.28
	3V_40%	120.900	96.321	.424	-108.77	350.57

*. The mean difference is significant at the 0.05 level.

Figure 4.11: Tests of equality of means and Post Hoc test for MOR values of 60% of salvaged lumber samples ,40% of salvaged lumber samples, and control samples.

Null Hypothesis: There is no significant differences in MOR values across different percentages of salvaged lumber in glulam. Alternate hypothesis: There is significant differences in MOE values across different percentages of salvaged lumber in glulam. This hypothesis tests if the MOR values differ across the three types of layups. As each sample was drawn independently of the other sample. So, values of MOR are assumed to be normally distributed. The results showed a significant difference between the percentage of lumber and MOR of glulam. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples (p=0.271>0.05) and the Control samples (p=0.424>0.05). Nevertheless, control samples have significantly more MOR on average than 60% of salvaged lumber samples (p=0.017<0.05). The null hypothesis that there is no significant difference in MOR values of glulam between the different percentages of salvaged lumber samples would be rejected. The alternate hypothesis that there is a significant difference in MOR values of glulam between the different percentages of salvaged lumber samples is accepted, as the p-value for the control sample is greater than 0.05).

Homogeneous Subsets

MOR

Tukey HSD[a]

		Subset for alpha = 0.05	
Percentage_salvaged	N	1	2
2V_60%	30	2308.86	
3V_40%	30	2458.56	2458.56
Control	30		2579.46
Sig.		.271	.424

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Figure 4.12: Scheffe test for MOR values of 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples

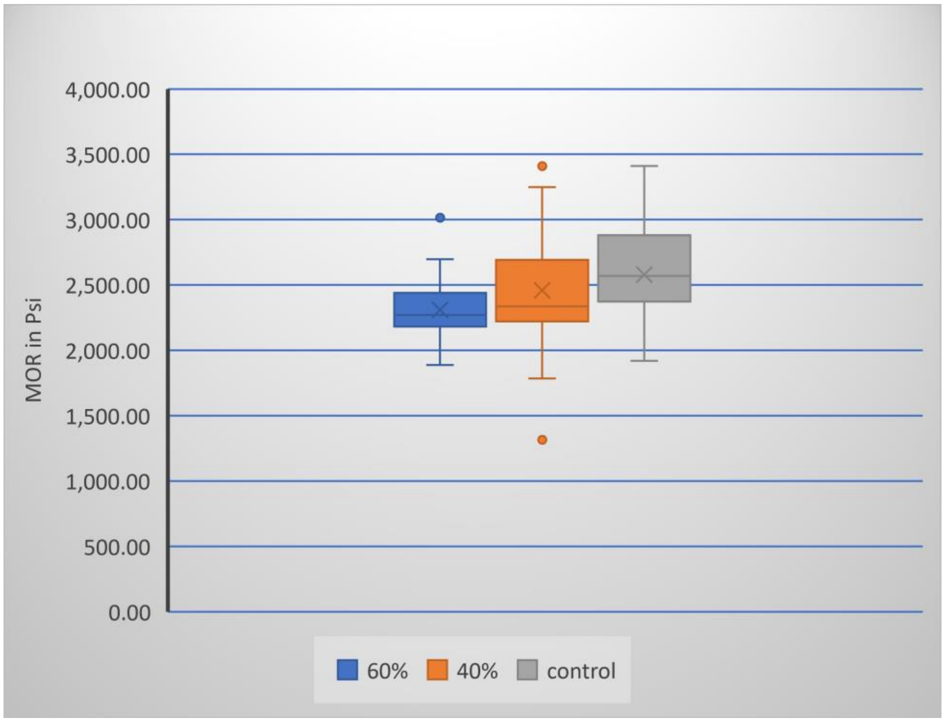


Figure 4.13: Graph of Mean of MOR values on y-axis vs Percentage salvage lumber on the x-axis for 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples

Mean MOR for 60% of salvaged lumber samples was around 2250 psi and standard deviation of 246.40, Mean MOR for 40% of salvaged lumber samples was around 2300 psi and standard deviation of 492.45 and that of control samples was around 2700 psi and standard deviation of 338.02.

4.4 Maximum flexural load

Oneway

Descriptives

Maximum_Flexural_Load

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
2V_60%	30	13006.56	1388.111	253.433	12488.23	13524.89	10640	16983
3V_40%	30	13877.13	2778.383	507.261	12839.66	14914.59	7408	19654
Control	30	14530.97	1904.202	347.658	13819.93	15242.01	10808	19211
Total	90	13804.89	2172.317	228.982	13349.91	14259.87	7408	19654

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
Maximum_Flexural_Load	Based on Mean	4.301	2	87	.017
	Based on Median	3.289	2	87	.042
	Based on Median and with adjusted df	3.289	2	62.199	.044
	Based on trimmed mean	4.304	2	87	.016

ANOVA

Maximum_Flexural_Load

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	35092155.79	2	17546077.90	3.966	.022
Within Groups	384895251.2	87	4424083.347		
Total	419987407.0	89			

Figure 4.14: Descriptive statistics and Test of homogeneity of variance for MOR values of 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples.

Robust Tests of Equality of Means

Maximum_Flexural_Load

	Statistic[a]	df1	df2	Sig.
Welch	6.394	2	54.310	.003
Brown-Forsythe	3.966	2	66.821	.024

a. Asymptotically F distributed.

Post Hoc Tests

Multiple Comparisons

Dependent Variable: Maximum_Flexural_Load

Tukey HSD

(I) Percentage_salvaged	(J) Percentage_salvaged	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
2V_60%	3V_40%	-870.566	543.083	.250	-2165.54	424.40
	Control	-1524.408*	543.083	.017	-2819.38	-229.44
3V_40%	2V_60%	870.566	543.083	.250	-424.40	2165.54
	Control	-653.843	543.083	.454	-1948.81	641.13
Control	2V_60%	1524.408*	543.083	.017	229.44	2819.38
	3V_40%	653.843	543.083	.454	-641.13	1948.81

*. The mean difference is significant at the 0.05 level.

Figure 4.15: Tests of equality of means and Post Hoc test for MOR values of 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples.

Null Hypothesis: There is no significant differences in maximum flexural strength values across different percentages of salvaged lumber in glulam. Alternate hypothesis: There is significant differences in maximum flexural strength values across different percentages of salvaged lumber in glulam. The results showed a significant difference between the percentage of lumber and maximum flexural strength. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples ($p=0.250>0.05$) and the Control samples ($p=0.454>0.05$). Nevertheless, control samples have significantly more maximum flexural strength on average than 60% of salvaged lumber samples samples ($p=0.017<0.05$). The null hypothesis that there is no significant difference in strength properties of glulam between the different percentages of salvaged lumber samples would be rejected.

Homogeneous Subsets

Maximum_Flexural_Load

Tukey HSD[a]

		Subset for alpha = 0.05	
Percentage_salvaged	N	1	2
2V_60%	30	13006.56	
3V_40%	30	13877.13	13877.13
Control	30		14530.97
Sig.		.250	.454

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 30.000.

Figure 4.16: Scheffe test for Maximum Flexural Load values of 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples

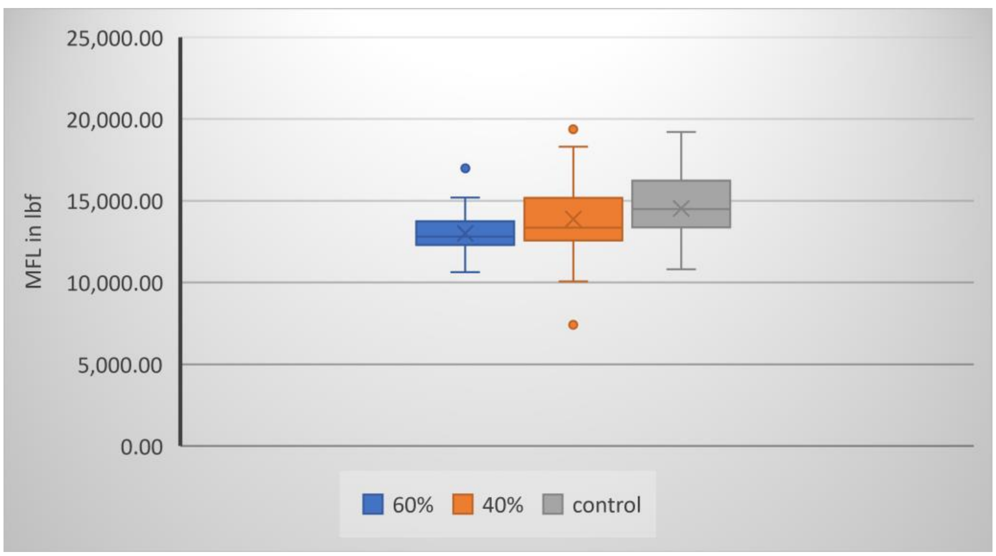


Figure 4.17: Graph of Mean of MFL values on y-axis vs Percentage salvage lumber on the x-axis for 40% of salvaged lumber samples, 60% of salvaged lumber samples, and control samples

Mean MFL for 60% of salvaged lumber samples was around 13006 lbf and standard deviation of 1388.111, Mean MFL for 40% of salvaged lumber samples was around 13877 lbf and standard deviation of 2778.383and that of control samples was around 14530 lbf and standard deviation of 1904.202.

4.5 Chapter summary

This chapter consists of data analysis. One-way ANOVA was used to analyze the collected data. One-way ANOVA was used on strength properties (MOE, MOR, and Maximum flexural load) of glulam on all three types of layups. The next chapter will focus on the conclusions and future areas for improvement.

CHAPTER 5
SUMMARY, CONTRIBUTIONS, AND FUTURE RESEARCH

The goal of this study is to characterize the suitability for salvaged lumber to be used as a feedstock for glulam and determine the physical and mechanical properties of such manufactured products against industry reference standards, such as ANSI/APA.

This research aims to find the answer to the following question: "Does the percentage of salvage lumber significantly influence the MOR, MOE, and Maximum flexural strength of glulam?"

There are three main objectives of this research:

1. To characterize the residual mechanical and physical properties of salvaged lumber of deconstructed homes of Michigan: Grading of lumber was done in two ways, mechanical grading and visual grading. Mechanical grading of salvaged lumber was decided based on the Modulus of elasticity (MOE) and Modulus of rupture (MOR) of salvaged lumber. These two parameters were selected based on ANSI/APA standard Glulam guide. Visual grading of salvaged lumber was also carried out based on the shorthand grading guide of the southern pine inspection bureau (SPIB). 97% of the samples had MOE above 1.4E6 SPF. Out of 68 samples, 43 samples were graded as 2.0E6 SPF based on MOE values obtained from Metrigaurd-340. 55 samples were graded as 1.8E6 SPF and 66 samples were graded as 1.4E6 SPF.
2. To manufacture glulam panels (GSL-Glu-laminated Salvaged Lumber) using a mixture of salvaged lumber and virgin lumber; and: After making salvaged lumber laminations and virgin lumber laminations structural glue (polyurethane) was applied on the faces of laminations. The resinated lumber was assembled into three specified lay-up patterns as shown in figure 3.14. Ready samples were then clamped in a clamping bed and pressed by

the manual press for 30 mins to bring the lumber into close contact. After 30 mins the glulam samples were removed from the clamping system. The samples were allowed to cure for 24 hours. After curing, beads of resin that squeezed out between the boards were removed before testing.

3. To analyze mechanical properties of Glulam panels manufactured with varying proportions of salvaged lumber against glulam samples made with virgin lumber:

- The results for One-way ANOVA for MOR values showed no significant difference between the percentage of lumber and MOE of glulam. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples ($p=0.999>0.05$) and the Control samples ($p=0.993>0.05$). Also, control samples are not significantly different than 60% of salvaged lumber samples ($p=986>0.05$). The null hypothesis that there is no significant difference in MOE of glulam between the different percentages of salvaged lumber samples would be accepted.
- The results for One-way ANOVA for MOR values showed a significant difference between the percentage of lumber and MOR of glulam. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples ($p=0.271>0.05$) and the Control samples ($p=0.424>0.05$). Nevertheless, control samples have significantly more MOR on average than 60% of salvaged lumber samples ($p=0.017<0.05$). The null hypothesis that there is no significant difference in MOR values of glulam between the different percentages of salvaged lumber samples would be rejected. The alternate hypothesis that there is a significant difference in MOR values of glulam between the different percentages of salvaged lumber samples is accepted, as the p-value for the control sample is greater than 0.05).

- The results for One-way ANOVA for MFL values showed a significant difference between the percentage of lumber and maximum flexural strength. Tukey post Hoc analysis revealed that 40% of salvaged lumber samples is not significantly different from 60% of salvaged lumber samples ($p=0.250>0.05$) and the Control samples ($p=0.454>0.05$). Nevertheless, control samples have significantly more maximum flexural strength on average than 60% of salvaged lumber samples ($p=0.017<0.05$). The null hypothesis that there is no significant difference in strength properties of glulam between the different percentages of salvaged lumber samples would be rejected.

Percentage of salvaged lumber	Reduction % when compared with control samples		
	MOR	MOE	MFL
40%	4.7%	4.50%	1.35%
60%	10.50%	10.50%	1.90%

Table 5.1 Showing percent reduction in MOE, MOR, and MFL values of samples

- The data concludes that when compared with control samples of glulam, the glulam manufactured with 60% of salvaged lumber had a reduction of 10.5% in MOR, 10.5% in MFL, and 1.9% in MOE as shown in table 4.1. when compared with control samples of glulam the glulam manufactured with 40% of salvaged lumber had a reduction of 4.7% in MOR, 4.5% in MFL, and 1.35% in MOE.
- These reduction percentages are less than 11% for all mechanical properties. In other words, we can say that even for glulam samples made of 60% of salvaged lumber the reduction percentage for all mechanical properties is going to be less than 11%. The reduction percentage for MOE between two consecutive grades turns out to be 33% approximately so we can safely say in absence of any data about a given salvaged sample

we can assume that MOE of that salvaged lumber will be one grade below the actual MOE of that sample before use.

- This research suggested that minor defects in salvaged lumber have only a small effect on mechanical properties of Glulam panel made of salved lumber as only 7% of samples slipped one grade below the original grade when graded visually.
- Glulam panel made of salved lumber can be used in places where were cross sectional area and weight doesn't play a crucial role. For example, in underground structure and foundations. The size of foundation going underground can be bigger in size and more in weight therefore bigger sized glulam panels can be made of salved lumbers and they can be used for foundation purpose. Additionally, these glulam panels made of salvaged lumber can be used in nonstructural places as well such as in partition walls and other members in the building which are not structural members.

5.2 Future Recommendations

The project findings encourage further research to boost this concept towards commercial use by testing the properties of such glulam panels made with various percentages of salvaged lumber on a larger scale.

- In this research age of tree, duration of loading, type of loading, moisture content of samples, and density of samples was not taken in the account. Future research can consider these multiple factors and collect larger number of samples to perform statistical analysis for more than two factors.
- Another governing factor which has potential to influence on the mechanical properties of the glulam samples is species of the tree from which samples are extracted. Future research

can be carried on different species of trees and their effect on the mechanical properties of glulam.

- This research was carried out on a very small scale so large sample size will help future research to get more precise results. Also, manufacturing glulam panels in factories with computer aided manufacturing process will help in bolstering the results obtained in this research. Also, automated and computer aided manufacturing process will reduce the chances of human error and will provide uniformity in manufacturing of glulam samples.

- We still don't have any standards for dealing with physical characteristics found in reclaimed wood (e.g., nail holes, fungus, decay, and other damages). Future research can concentrate on developing a standard based on such study where salvaged lumber can be graded based on the in-service damages as well.
- Future studies can concentrate on effect of type of glue on mechanical properties of Glulam manufactured with salvaged lumber and try to answer the following research question: Can conventional PUR adhesives be replaced with a non-toxic biodegradable alternative such as lignin? This research will help to replace the commonly used toxic and non-biodegradable adhesives with biodegradable adhesives such as lignin.

APPENDICES

APPENDIX A

MFL and MOR values of raw 186 samples

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
1	1c	25.4	25.4	513.82	9.07	10,790.22	1,311,931.13
2	4b	25.4	25.4	444.56	10.28	9,335.76	1,052,187.70
3	5B	25.4	25.4	376.91	6.8	7,915.11	1,137,494.19
4	6A	25.4	25.4	698.25	11.96	14,663.25	1,633,297.57
5	7A	25.4	25.4	612.88	13.07	12,870.48	1,595,807.54
6	8A	25.4	25.4	483.22	7.9	10,147.62	1,458,909.19
7	9B	25.4	25.4	565.36	11.08	11,872.56	1,480,686.06
8	31A	25.4	25.4	491.27	10.01	10,316.67	1,177,750.45
9	30A	25.4	25.4	388.18	8.38	8,151.78	996,373.50
10	29A	25.4	25.4	558.92	10.96	11,737.32	1,323,818.26
11	28B	25.4	25.4	305.23	7.79	6,409.83	1,091,803.72
12	27A	25.4	25.4	591.13	12.29	12,413.73	1,321,102.66
13	26B	25.4	25.4	548.45	8.04	11,517.45	1,449,260.98
14	25B	25.4	25.4	299.6	7.45	6,291.60	1,170,489.49
15	24A	25.4	25.4	501.74	13.05	10,536.54	1,303,130.17
16	23A	25.4	25.4	308.45	7.63	6,477.45	920,278.49
17	22A	25.4	25.4	414.76	10.62	8,709.96	1,032,574.05
18	41A	25.4	25.4	532.34	11.78	11,179.14	1,367,515.48
19	40A	25.4	25.4	319.73	6.82	6,714.33	918,509.56
20	39A	25.4	25.4	464.69	7.69	9,758.49	1,273,184.19
21	38A	25.4	25.4	425.23	7.56	8,929.83	1,206,640.41
22	37A	25.4	25.4	483.22	9.62	10,147.62	1,134,418.87
23	36A	25.4	25.4	463.89	7.49	9,741.69	1,345,651.36
24	35B	25.4	25.4	328.59	5.53	6,900.39	1,237,263.05
25	34A	25.4	25.4	440.53	9.2	9,251.13	1,220,032.61
26	33A	25.4	25.4	380.13	7.01	7,982.73	1,158,519.06
27	32A	25.4	25.4	498.52	10.81	10,468.92	1,101,553.25
28	48A	25.4	25.4	511.4	12.7	10,739.40	1,275,284.30
29	47A	25.4	25.4	289.13	5.2	6,071.73	1,260,196.48
30	46A	25.4	25.4	628.18	10.09	13,191.78	1,415,894.92

Table 6.1: MFL and MOR values of 186 samples

Table 6.1 (Cont'd)

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
31	45A	25.4	25.4	467.91	9.39	9,826.11	1,059,257.61
32	44B	25.4	25.4	436.51	7.84	9,166.71	1,178,408.39
33	43A	25.4	25.4	387.38	7.98	8,134.98	1,164,491.80
34	42A	25.4	25.4	394.63	7.34	8,287.23	1,090,355.70
35	58A	25.4	25.4	714.35	11.13	15,001.35	1,636,469.30
36	57A	25.4	25.4	439.73	9.43	9,234.33	1,201,108.20
37	56A	25.4	25.4	645.9	7.9	13,563.90	1,693,345.12
38	55A	25.4	25.4	235.17	5.79	4,938.57	982,815.75
39	54A	25.4	25.4	477.58	10.64	10,029.18	1,264,976.17
40	53A	25.4	25.4	454.22	9.77	9,538.62	1,166,387.35
41	52A	25.4	25.4	619.32	12.33	13,005.72	1,579,627.17
42	51A	25.4	25.4	530.73	9.59	11,145.33	1,382,680.05
43	50A	25.4	25.4	545.23	14.03	11,449.83	1,268,741.40
44	49A	25.4	25.4	504.16	7.54	10,587.36	1,486,968.02
45	68A	25.4	25.4	436.51	7.01	9,166.71	1,496,250.77
46	67B	25.4	25.4	283.49	6.59	5,953.29	895,942.60
47	66A	25.4	25.4	506.57	11.03	10,637.97	1,281,407.97
48	65A	25.4	25.4	355.17	5.6	7,458.57	1,274,902.65
49	64A	25.4	25.4	537.98	11.51	11,297.58	1,390,963.39
50	63A	25.4	25.4	523.48	10.54	10,993.08	1,271,241.49
51	62A	25.4	25.4	504.16	10.9	10,587.36	1,325,660.06
52	61A	25.4	25.4	506.57	11.85	10,637.97	1,325,007.08
53	60A	25.4	25.4	468.72	9.01	9,843.12	1,375,883.40
54	59A	25.4	25.4	177.99	5.9	3,737.79	755,306.85
55	78A	25.4	25.4	579.86	11.64	12,177.06	1,441,127.83
56	77A	25.4	25.4	508.18	10.31	10,671.78	1,305,408.67
57	76A	25.4	25.4	556.5	11.55	11,686.50	1,469,769.85
58	75B	25.4	25.4	519.46	9.99	10,908.66	1,567,393.42
59	74A	25.4	25.4	506.57	8.61	10,637.97	1,355,152.89
60	73A	25.4	25.4	340.67	6.82	7,154.07	1,286,518.56
61	72A	25.4	25.4	583.08	10.68	12,244.68	1,544,388.24
62	71A	25.4	25.4	624.96	14.23	13,124.16	1,698,816.89

Table 6.1 (Cont'd)

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
63	70A	25.4	25.4	525.9	12.42	11,043.90	1,272,231.30
64	69B	25.4	25.4	326.17	6.97	6,849.57	1,118,392.28
65	88B	25.4	25.4	622.54	12.24	13,073.34	1,608,570.04
66	87A	25.4	25.4	592.74	14.85	12,447.54	1,536,825.55
67	86A	25.4	25.4	480.8	9.89	10,096.80	1,175,632.15
68	85A	25.4	25.4	395.43	5.88	8,304.03	1,366,567.84
69	84A	25.4	25.4	454.22	9.29	9,538.62	1,299,344.44
70	83B	25.4	25.4	318.92	5.28	6,697.32	1,264,237.45
71	82A	25.4	25.4	587.11	12.05	12,329.31	1,528,597.35
72	81A	25.4	25.4	336.64	5.9	7,069.44	1,136,664.86
73	80A	25.4	25.4	895.56	11.37	18,806.76	2,032,897.31
74	79A	25.4	25.4	507.38	10.12	10,654.98	1,437,226.97
75	96B	25.4	25.4	568.58	14.46	11,940.18	1,515,297.66
76	95A	25.4	25.4	133.69	4.5	2,807.49	671,453.74
77	94B	25.4	25.4	533.95	9.37	11,212.95	1,511,353.95
78	93A	25.4	25.4	600.8	12.74	12,616.80	1,333,894.41
79	92A	25.4	25.4	666.84	13.5	14,003.64	1,745,922.22
80	91A	25.4	25.4	602.41	9.83	12,650.61	1,784,595.38
81	90A	25.4	25.4	559.72	12.01	11,754.12	1,393,600.06
82	89A	25.4	25.4	492.88	10	10,350.48	1,592,216.02
83	106A	25.4	25.4	527.51	10.11	11,077.71	1,517,667.09
84	107A	25.4	25.4	454.22	10.73	9,538.62	1,122,964.59
85	105A	25.4	25.4	422.01	8.58	8,862.21	1,151,946.05
86	104B	25.4	25.4	353.55	8.69	7,424.55	1,125,708.92
87	103A	25.4	25.4	486.44	13.65	10,215.24	1,250,402.52
88	102B	25.4	25.4	366.44	4.74	7,695.24	1,627,181.68
89	101B	25.4	25.4	696.63	8.95	14,629.23	1,944,057.68
90	100B	25.4	25.4	492.88	10.28	10,350.48	1,536,648.22
91	99A	25.4	25.4	550.06	11.41	11,551.26	1,422,045.65
92	136A	25.4	25.4	859.32	12.15	18,045.72	2,112,386.15
93	116A	25.4	25.4	382.55	8.15	8,033.55	1,238,098.03
94	115A	25.4	25.4	264.97	6.16	5,564.37	1,060,942.49

Table 6.1 (Cont'd)

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
95	114A	25.4	25.4	376.91	6.4	7,915.11	1,334,153.13
96	113A	25.4	25.4	761.06	10.94	15,982.26	1,984,216.06
97	112A	25.4	25.4	604.82	10.51	12,701.22	1,507,738.89
98	111A	25.4	25.4	679.72	11.65	14,274.12	1,598,495.44
99	110B	25.4	25.4	196.51	6.22	4,126.71	1,016,853.05
100	109A	25.4	25.4	463.89	8.01	9,741.69	1,462,616.04
101	108A	25.4	25.4	442.14	7.75	9,284.94	1,395,031.07
102	117A	25.4	25.4	392.21	6.26	8,236.41	1,615,081.41
103	118A	25.4	25.4	106.31	4.09	2,232.51	564,258.48
104	119A	25.4	25.4	639.45	13.05	13,428.45	1,610,252.54
105	120A	25.4	25.4	646.7	9.67	13,580.70	1,864,399.87
106	121A	25.4	25.4	495.3	11.64	10,401.30	1,361,644.84
107	122B	25.4	25.4	450.2	7.99	9,454.20	1,444,347.64
108	123A	25.4	25.4	624.15	12.64	13,107.15	1,670,033.19
109	124A	25.4	25.4	451	8.13	9,471.00	1,388,719.58
110	125A	25.4	25.4	591.94	10.39	12,430.74	1,416,569.52
111	126B	25.4	25.4	380.13	7.01	7,982.73	1,367,609.55
112	127B	25.4	25.4	734.49	10.3	15,424.29	2,047,565.53
113	128A	25.4	25.4	475.16	9.23	9,978.36	1,387,634.43
114	129B	25.4	25.4	236.78	4.57	4,972.38	1,034,977.34
115	130B	25.4	25.4	225.5	6.76	4,735.50	953,764.95
116	131A	25.4	25.4	591.13	8.81	12,413.73	1,860,029.88
117	132A	25.4	25.4	552.48	8.67	11,602.08	1,581,763.19
118	133A	25.4	25.4	612.88	11.81	12,870.48	1,715,133.02
119	134A	25.4	25.4	782	15.24	16,422.00	1,898,480.17
120	135B	25.4	25.4	549.26	11.14	11,534.46	1,432,890.57
121	137A	25.4	25.4	227.11	12.29	4,769.31	586,722.73
122	138B	25.4	25.4	356.78	5.23	7,492.38	1,527,098.28
123	139A	25.4	25.4	712.74	13.22	14,967.54	1,725,684.35
124	140A	25.4	25.4	482.41	6.84	10,130.61	1,604,110.43
125	141A	25.4	25.4	431.67	6.71	9,065.07	1,393,810.31
126	142A	25.4	25.4	612.07	9.98	12,853.47	1,510,827.40

Table 6.1 (Cont'd)

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
127	143A	25.4	25.4	670.86	8.62	14,088.06	1,961,532.27
128	144A	25.4	25.4	697.44	8.04	14,646.24	2,055,788.16
129	145A	25.4	25.4	571	10.96	11,991.00	1,632,414.70
130	146A	25.4	25.4	568.58	10.9	11,940.18	1,445,922.84
131	147A	25.4	25.4	645.9	13.62	13,563.90	1,576,180.83
132	148A	25.4	25.4	299.6	8.92	6,291.60	987,844.37
133	149A	25.4	25.4	517.04	6.72	10,857.84	1,619,767.58
134	150A	25.4	25.4	538.79	9.93	11,314.59	1,485,537.60
135	151A	25.4	25.4	509.79	9.42	10,705.59	1,427,988.38
136	152A	25.4	25.4	722.41	12.65	15,170.61	1,766,900.69
137	153A	25.4	25.4	554.89	10.44	11,652.69	1,534,296.53
138	154A	25.4	25.4	332.62	6.4	6,985.02	1,363,218.14
139	155B	25.4	25.4	609.66	11.78	12,802.86	1,637,513.61
140	156A	25.4	25.4	741.73	13.17	15,576.33	1,914,347.29
141	157A	25.4	25.4	441.34	7.78	9,268.14	1,257,233.09
142	158A	25.4	25.4	666.03	9.95	13,986.63	1,642,700.63
143	159B	25.4	25.4	389.8	7.99	8,185.80	1,177,038.76
144	160A	25.4	25.4	662.81	11.82	13,919.01	1,729,390.59
145	161B	25.4	25.4	525.09	11.26	11,026.89	1,381,976.69
146	162A	25.4	25.4	637.84	10.82	13,394.64	1,523,372.04
147	163A	25.4	25.4	196.51	7.62	4,126.71	1,019,782.87
148	164B	25.4	25.4	876.23	9.65	18,400.83	2,294,273.58
149	165A	25.4	25.4	614.49	9.67	12,904.29	1,581,372.07
150	166A	25.4	25.4	403.49	5.27	8,473.29	1,619,517.46
151	167A	25.4	25.4	458.25	5.3	9,623.25	1,993,467.65
152	168A	25.4	25.4	384.96	9.39	8,084.16	1,167,953.13
153	169A	25.4	25.4	512.21	11.66	10,756.41	1,356,860.72
154	170A	25.4	25.4	579.86	11.58	12,177.06	1,711,267.22
155	171B	25.4	25.4	777.17	11.92	16,320.57	1,738,878.40
156	172B	25.4	25.4	258.52	4.77	5,428.92	1,135,972.71
157	173B	25.4	25.4	361.61	6.24	7,593.81	1,477,280.98
158	174A	25.4	25.4	404.29	6.93	8,490.09	1,451,690.40

Table 6.1 (Cont'd)

SR NO	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max. load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
159	175A	25.4	25.4	732.07	10.22	15,373.47	2,059,695.10
160	176A	25.4	25.4	695.83	9.65	14,612.43	2,194,450.49
161	167A	25.4	25.4	458.25	5.3	9,623.25	1,993,467.65
162	168A	25.4	25.4	384.96	9.39	8,084.16	1,167,953.13
163	169A	25.4	25.4	512.21	11.66	10,756.41	1,356,860.72
164	170A	25.4	25.4	579.86	11.58	12,177.06	1,711,267.22
165	171B	25.4	25.4	777.17	11.92	16,320.57	1,738,878.40
166	172B	25.4	25.4	258.52	4.77	5,428.92	1,135,972.71
167	173B	25.4	25.4	361.61	6.24	7,593.81	1,477,280.98
168	174A	25.4	25.4	404.29	6.93	8,490.09	1,451,690.40
169	175A	25.4	25.4	732.07	10.22	15,373.47	2,059,695.10
170	176A	25.4	25.4	695.83	9.65	14,612.43	2,194,450.49
171	177B	25.4	25.4	220.67	9.74	4,634.07	1,252,822.27
172	178B	25.4	25.4	87.79	2.95	1,843.59	0
173	179B	25.4	25.4	471.14	8.31	9,893.94	1,574,055.85
174	180A	25.4	25.4	569.39	9.85	11,957.19	1,404,668.12
175	181B	25.4	25.4	515.43	8.3	10,824.03	1,643,890.69
176	182A	25.4	25.4	430.87	13.09	9,048.27	1,336,496.15
177	183A	25.4	25.4	358.39	6.28	7,526.19	1,252,074.51
178	184B	25.4	25.4	545.23	6.49	11,449.83	1,817,144.54
179	185A	25.4	25.4	379.33	6.92	7,965.93	1,359,780.00
180	186B	25.4	25.4	475.97	7.91	9,995.37	1,299,367.02
181	187A	25.4	25.4	166.71	4.96	3,500.91	1,136,208.76
182	191 A	25.4	25.4	494.49	12.05	10,384.29	1,417,713.59
183	190 A	25.4	25.4	496.91	13.75	10,435.11	1,072,324.49
184	189 A	25.4	25.4	611.27	9.7	12,836.67	1,574,646.78
185	188 A	25.4	25.4	8.06	3.55	169.26	6,859,858.77
186	OUTLIER	25.4	25.4	572.61	11.66	12,024.81	1,700,098.33

APPENDIX B

MOE values of raw samples obtained from Metriguard

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1	1.98	4	0.553	62.6	15.8	3.77
	2	1.98	4	0.553	62.6	15.8	3.78
	3	1.98	4	0.553	62.6	15.8	3.78
	4	2.06	4	0.57	64.6	15.8	3.79
	5	2.06	4	0.57	64.6	15.8	3.79
	6	2.06	4	0.569	64.4	15.8	3.8
2	1	2.63	1	0.708	80.9	16	3.77
	2	2.63	1	0.708	80.9	16	3.77
	3	2.63	1	0.708	80.9	16	3.77
	4	2.72	1	0.736	84.1	16	3.76
	5	2.72	1	0.735	84	16	3.77
	6	2.73	1	0.736	84.1	16	3.77
3	1	2.18	3	0.635	72.6	16	3.62
	2	2.17	3	0.635	72.6	16	3.62
	3	2.16	3	0.635	72.6	16	3.61
	4	2.21	3	0.645	73.8	16	3.62
	5	2.21	3	0.646	73.9	16	3.61
	6	2.22	3	0.647	74	16	3.62
4	1	1.95	4	0.506	57.9	16	3.86
	2	1.96	4	0.506	57.9	16	3.86
	3	1.95	4	0.505	57.7	16	3.86
	4	2.04	4	0.53	60.6	16	3.85
	5	2.04	4	0.531	60.7	16	3.85
	6	2.04	4	0.532	60.8	16	3.84
5	1	2.06	4	0.569	64.9	16	3.75
	2	2.05	4	0.569	64.9	16	3.75
	3	2.06	4	0.569	64.9	16	3.75
	4	2.18	3	0.603	68.7	16	3.75
	5	2.17	3	0.602	68.6	16	3.75
	6	2.18	3	0.603	68.7	16	3.75

Table 6.2: MOE values of raw sample obtained from Metriguard

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
6	1	1.99	4	0.611	69.9	16	3.53
	2	1.99	4	0.613	70.1	16	3.52
	3	1.99	4	0.612	70	16	3.52
	4	1.89	4	0.583	66.6	16	3.52
	5	1.9	4	0.584	66.7	16	3.53
	6	1.9	4	0.584	66.7	16	3.52
7	1	1.33	4	0.539	61.6	16	3.07
	2	1.33	4	0.541	61.9	16	3.07
	3	1.33	4	0.539	61.6	16	3.07
	4	1.32	4	0.537	61.4	16	3.06
	5	1.32	4	0.537	61.4	16	3.06
	6	1.33	4	0.539	61.6	16	3.07
8	1	2.11	3	0.569	64.3	15.8	3.85
	2	2.13	3	0.568	64.2	15.8	3.87
	3	2.09	4	0.569	64.3	15.8	3.84
	4	2.11	3	0.577	65.2	15.8	3.82
	5	2.09	4	0.577	65.2	15.8	3.81
	6	2.1	3	0.577	65.2	15.8	3.82
9	1	2.83	1	0.664	75.9	16	4.03
	2	2.85	1	0.664	75.9	16	4.05
	3	2.85	1	0.665	76	16	4.05
	4	2.77	1	0.64	73.1	16	4.06
	5	2.75	1	0.64	73.1	16	4.05
	6	2.74	1	0.639	73	16	4.05
10	1	1.94	4	0.537	60.7	15.8	3.81
	2	1.95	4	0.537	60.7	15.8	3.81
	3	1.96	4	0.537	60.7	15.8	3.82
	4	1.95	4	0.539	60.9	15.8	3.81
	5	1.94	4	0.539	60.9	15.8	3.79
	6	1.93	4	0.539	60.9	15.8	3.79
11	1	1.56	4	0.549	62.8	15.8	3.37
	2	1.56	4	0.55	62.9	15.8	3.37
	3	1.55	4	0.549	62.8	15.8	3.37
	4	1.54	4	0.543	62.1	15.8	3.37

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	5	1.54	4	0.544	62.2	15.8	3.37
	6	1.54	4	0.543	62.1	15.8	3.37
12	1	1.87	4	0.562	64.3	15.8	3.64
	2	1.86	4	0.562	64.3	15.8	3.64
	3	1.86	4	0.56	64.1	15.8	3.64
	4	1.77	4	0.539	61.6	15.8	3.63
	5	1.77	4	0.539	61.6	15.8	3.63
	6	1.77	4	0.537	61.4	15.8	3.63
13	1	2.34	3	0.625	71.4	16	3.78
	2	2.33	3	0.625	71.4	16	3.78
	3	2.33	3	0.625	71.4	16	3.78
	4	2.48	2	0.67	76.6	16	3.76
	5	2.48	2	0.668	76.4	16	3.77
	6	2.48	2	0.667	76.3	16	3.77
14	1	2.94	1	0.699	79.9	16	4.01
	2	2.94	1	0.7	80	16	4.01
	3	2.94	1	0.699	79.9	16	4.01
	4	2.81	1	0.671	76.7	16	4.01
	5	2.82	1	0.671	76.7	16	4.01
	6	2.82	1	0.673	77	16	4.01
15	1	2.91	1	0.648	74.1	16	4.14
	2	2.9	1	0.647	74	16	4.14
	3	2.91	1	0.648	74.1	16	4.14
	4	2.69	1	0.598	68.4	16	4.15
	5	2.69	1	0.598	68.4	16	4.15
	6	2.69	1	0.597	68.3	16	4.15
16	1	1.81	4	0.521	59.9	15.9	3.7
	2	1.82	4	0.52	59.8	15.9	3.71
	3	1.81	4	0.519	59.7	15.9	3.7
	4	1.76	4	0.514	59.1	15.9	3.67
	5	1.74	4	0.513	59	15.9	3.66
	6	1.75	4	0.515	59.2	15.9	3.66
17	1	1.48	4	0.512	59.1	16	3.35

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	2	1.49	4	0.512	59.1	16	3.35
	3	1.48	4	0.512	59.1	16	3.35
	4	1.53	4	0.524	60.5	16	3.36
	5	1.53	4	0.524	60.5	16	3.36
	6	1.53	4	0.525	60.6	16	3.37
18	1	2.24	3	0.611	69.8	16	3.77
	2	2.26	3	0.611	69.8	16	3.78
	3	2.24	3	0.611	69.8	16	3.77
	4	2.19	3	0.608	69.4	16	3.73
	5	2.19	3	0.608	69.4	16	3.73
	6	2.21	3	0.608	69.4	16	3.75
19	1	2.24	3	0.563	64.5	15.9	3.98
	2	2.23	3	0.562	64.4	15.9	3.99
	3	2.23	3	0.561	64.3	15.9	3.98
	4	2.33	3	0.587	67.3	15.9	3.99
	5	2.33	3	0.587	67.3	15.9	3.98
	6	2.33	3	0.586	67.1	15.9	3.98
20	1	2.09	4	0.601	69.4	16	3.67
	2	2.09	4	0.6	69.3	16	3.67
	3	2.1	3	0.602	69.6	16	3.68
	4	2.12	3	0.607	70.1	16	3.68
	5	2.12	3	0.607	70.1	16	3.68
	6	2.12	3	0.605	69.9	16	3.68
21	1	2.31	3	0.654	74.7	16	3.69
	2	2.31	3	0.653	74.6	16	3.69
	3	2.31	3	0.653	74.6	16	3.69
	4	2.25	3	0.636	72.6	16	3.69
	5	2.25	3	0.636	72.6	16	3.69
	6	2.25	3	0.636	72.6	16	3.69
22	1	2.1	3	0.583	66.5	16	3.75
	2	2.1	3	0.584	66.6	16	3.74
	3	2.1	4	0.582	66.3	16	3.74
	4	2.01	4	0.56	63.8	16	3.74
	5	2.01	4	0.56	63.8	16	3.74

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	6	2.01	4	0.559	63.7	16	3.74
23	1	2.26	3	0.661	75.5	16	3.63
	2	2.26	3	0.661	75.5	16	3.64
	3	2.27	3	0.661	75.5	16	3.64
	4	2.21	3	0.645	73.7	16	3.64
	5	2.2	3	0.644	73.6	16	3.64
	6	2.21	3	0.644	73.6	16	3.64
24	1	2.24	3	0.619	70.7	16	3.75
	2	2.25	3	0.619	70.7	16	3.75
	3	2.24	3	0.618	70.6	16	3.75
	4	2.27	3	0.628	71.7	16	3.74
	5	2.27	3	0.628	71.7	16	3.74
	6	2.27	3	0.627	71.6	16	3.74
25	1	1.94	4	0.53	60.5	16	3.76
	2	1.94	4	0.53	60.5	16	3.76
	3	1.94	4	0.53	60.5	16	3.76
	4	2.07	4	0.565	64.5	16	3.77
	5	2.07	4	0.565	64.5	16	3.77
	6	2.07	4	0.565	64.5	16	3.77
26	1	1.03	4	0.532	60.2	15.8	2.79
	2	1.02	4	0.532	60.2	15.8	2.78
	3	1.03	4	0.532	60.2	15.8	2.79
	4	0.94	8	0.486	55	15.8	2.79
	5	0.94	8	0.486	55	15.8	2.79
	6	0.94	8	0.485	54.9	15.8	2.79
27	1	1.72	4	0.547	61.6	15.8	3.59
	2	1.72	4	0.548	61.8	15.8	3.59
	3	1.73	4	0.548	61.8	15.8	3.59
	4	1.67	4	0.532	59.9	15.8	3.59
	5	1.67	4	0.531	59.8	15.8	3.59
	6	1.67	4	0.533	60	15.8	3.59
28	1	1.75	4	0.552	62.4	15.8	3.57
	2	1.75	4	0.553	62.6	15.8	3.57

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	3	1.75	4	0.553	62.6	15.8	3.57
	4	1.72	4	0.541	61.2	15.8	3.58
	5	1.71	4	0.539	61	15.8	3.58
	6	1.72	4	0.54	61.1	15.8	3.58
29	1	1.73	4	0.603	67.9	15.8	3.42
	2	1.74	4	0.603	67.9	15.8	3.43
	3	1.73	4	0.603	67.9	15.8	3.43
	4	1.67	4	0.585	65.9	15.8	3.42
	5	1.67	4	0.585	65.9	15.8	3.42
	6	1.67	4	0.584	65.8	15.8	3.42
30	1	1.85	4	0.532	60.8	16	3.66
	2	1.85	4	0.533	61	16	3.66
	3	1.86	4	0.532	60.8	16	3.67
	4	1.93	4	0.549	62.8	16	3.69
	5	1.92	4	0.548	62.7	16	3.68
	6	1.93	4	0.549	62.8	16	3.68
31	1	2.25	3	0.664	75.9	16	3.62
	2	2.26	3	0.664	75.9	16	3.62
	3	2.25	3	0.665	76	16	3.62
	4	2.44	2	0.72	82.3	16	3.62
	5	2.45	2	0.719	82.2	16	3.62
	6	2.45	2	0.72	82.3	16	3.62
32	1	2.51	2	0.65	73.8	15.9	3.91
	2	2.5	2	0.65	73.8	15.9	3.9
	3	2.51	2	0.652	74	15.9	3.9
	4	2.36	3	0.617	70	15.9	3.89
	5	2.36	3	0.615	69.7	15.9	3.89
	6	2.36	3	0.615	69.7	15.9	3.9
33	1	3.48	1	0.744	85	16	4.23
	2	3.49	1	0.745	85.1	16	4.24
	3	3.5	1	0.747	85.4	16	4.24
	4	3.58	1	0.763	87.2	16	4.24
	5	3.57	1	0.761	87	16	4.24
	6	3.58	1	0.763	87.2	16	4.25

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
34	1	2.35	3	0.579	64.7	16	3.95
	2	2.36	3	0.58	64.8	16	3.95
	3	2.35	3	0.579	64.7	16	3.95
	4	2.5	2	0.622	69.5	16	3.93
	5	2.5	2	0.621	69.4	16	3.93
	6	2.51	2	0.623	69.6	16	3.93
35	1	2.41	2	0.699	79.2	15.8	3.71
	2	2.4	2	0.699	79.2	15.8	3.71
	3	2.4	2	0.699	79.2	15.8	3.71
	4	2.22	3	0.642	72.6	15.8	3.72
	5	2.22	3	0.644	72.8	15.8	3.71
	6	2.23	3	0.644	72.8	15.8	3.72
36	1	2.23	3	0.64	74.4	16	3.66
	2	2.23	3	0.64	74.4	16	3.66
	3	2.23	3	0.642	74.7	16	3.66
	4	2.38	3	0.686	79.9	16	3.65
	5	2.38	3	0.684	79.6	16	3.65
	6	2.38	3	0.686	79.9	16	3.65
37	1	2.41	2	0.649	74.2	16	3.77
	2	2.4	3	0.647	74	16	3.77
	3	2.41	2	0.649	74.2	16	3.77
	4	2.53	2	0.693	79.2	16	3.75
	5	2.54	2	0.693	79.2	16	3.75
	6	2.53	2	0.693	79.2	16	3.75
38	1	2.33	3	0.602	68.8	16	3.85
	2	2.33	3	0.603	68.9	16	3.85
	3	2.34	3	0.602	68.8	16	3.86
	4	2.21	3	0.565	64.7	16	3.87
	5	2.22	3	0.565	64.7	16	3.88
	6	2.22	3	0.566	64.8	16	3.88
39	1	2.08	4	0.523	59.8	16	3.9
	2	2.08	4	0.524	59.9	16	3.9
	3	2.08	4	0.523	59.8	16	3.9

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	4	2.13	3	0.538	61.6	16	3.89
	5	2.14	3	0.54	61.8	16	3.89
	6	2.13	3	0.538	61.6	16	3.9
40	1	2.1	4	0.577	65.9	16	3.74
	2	2.11	3	0.579	66.2	16	3.74
	3	2.1	4	0.578	66	16	3.74
	4	2.23	3	0.612	70	16	3.75
	5	2.23	3	0.612	70	16	3.75
	6	2.23	3	0.613	70.1	16	3.74
41	1	1.93	4	0.523	59.1	15.8	3.85
	2	1.93	4	0.523	59.1	15.8	3.85
	3	1.93	4	0.523	59.1	15.8	3.85
	4	2.01	4	0.544	61.6	15.8	3.85
	5	2.01	4	0.543	61.4	15.8	3.85
	6	2.01	4	0.543	61.4	15.8	3.85
42	1	2.41	2	0.654	74.8	16	3.76
	2	2.43	2	0.654	74.8	16	3.78
	3	2.41	2	0.654	74.8	16	3.77
	4	2.45	2	0.667	76.2	16	3.76
	5	2.45	2	0.667	76.2	16	3.76
	6	2.44	2	0.667	76.2	16	3.76
43	1	1.76	4	0.611	69.8	16	3.33
	2	1.75	4	0.609	69.5	16	3.33
	3	1.76	4	0.612	69.9	16	3.33
	4	1.84	4	0.638	72.9	16	3.33
	5	1.99	4	0.664	75.8	16	3.39
	6	1.82	4	0.634	72.4	16	3.33
44	1	1.8	4	0.501	57.2	16	3.72
	2	1.58	4	0.522	59.7	16	3.41
	3	1.8	4	0.501	57.2	16	3.72
	4	1.91	4	0.526	60.1	16	3.74
	5	1.85	4	0.513	58.6	16	3.73
	6	1.85	4	0.513	58.6	16	3.72

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
45	1	1.87	4	0.549	62.7	16	3.63
	2	1.88	4	0.55	62.8	16	3.63
	3	1.87	4	0.548	62.6	16	3.63
	4	1.9	4	0.571	65.2	16	3.57
	5	1.82	4	0.534	61	16	3.63
	6	1.9	4	0.551	62.9	16	3.64
46	1	2.45	2	0.653	74.7	16	3.8
	2	2.46	2	0.655	74.9	16	3.8
	3	2.45	2	0.654	74.8	16	3.8
	4	2.34	3	0.627	71.6	16	3.79
	5	2.35	3	0.628	71.7	16	3.8
	6	2.42	2	0.636	72.7	16	3.83
47	1	2.58	2	0.695	79.4	16	3.78
	2	2.58	2	0.694	79.3	16	3.79
	3	2.62	1	0.706	80.7	16	3.78
	4	2.69	1	0.727	83	16	3.78
	5	2.68	1	0.726	82.9	16	3.77
	6	2.68	1	0.724	82.7	16	3.78
48	1	2.97	1	0.719	81.7	15.9	4.03
	2	2.98	1	0.718	81.6	15.9	4.04
	3	2.98	1	0.718	81.6	15.9	4.04
	4	2.87	1	0.695	79	15.9	4.03
	5	2.86	1	0.695	79	15.9	4.02
	6	2.88	1	0.695	79	15.9	4.03
49	1	2.48	2	0.609	69.5	16	3.96
	2	2.48	2	0.608	69.4	16	3.96
	3	2.49	2	0.611	69.8	16	3.96
	4	2.42	2	0.591	67.6	16	3.97
	5	2.42	2	0.592	67.7	16	3.97
	6	2.41	2	0.596	68.1	16	3.94
50	1	1.88	4	0.576	65.8	16	3.54
	2	1.88	4	0.576	65.8	16	3.55
	3	1.89	4	0.578	66	16	3.54
	4	1.78	4	0.545	62.2	16	3.54

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	5	1.79	4	0.545	62.2	16	3.56
	6	1.79	4	0.547	62.4	16	3.55
51	1	1.43	4	0.505	57.7	16	3.3
	2	1.43	4	0.506	57.8	16	3.3
	3	1.43	4	0.505	57.7	16	3.3
	4	1.47	4	0.518	59.2	16	3.31
	5	1.47	4	0.519	59.3	16	3.31
	6	1.47	4	0.518	59.2	16	3.31
52	1	2.1	3	0.593	67.8	16	3.69
	2	2.1	4	0.593	67.8	16	3.69
	3	2.09	4	0.591	67.6	16	3.69
	4	2.34	3	0.665	75.9	16	3.68
	5	2.35	3	0.666	76	16	3.69
	6	2.34	3	0.664	75.8	16	3.68
53	1	1.74	4	0.541	61.6	15.9	3.54
	2	1.75	4	0.544	62	15.9	3.54
	3	1.74	4	0.542	61.7	15.9	3.54
	4	1.7	4	0.523	59.5	15.9	3.57
	5	1.7	4	0.523	59.5	15.9	3.57
	6	1.7	4	0.523	59.5	15.9	3.56
54	1	1.67	4	0.654	74.1	15.8	3.19
	2	1.68	4	0.657	74.3	15.8	3.19
	3	1.67	4	0.654	74.1	15.8	3.19
	4	1.65	4	0.646	73.1	15.8	3.19
	5	1.66	4	0.648	73.4	15.8	3.2
	6	1.65	4	0.646	73.1	15.8	3.19
55	1	2.47	2	0.649	74.2	16	3.82
	2	2.46	2	0.649	74.2	16	3.82
	3	2.46	2	0.649	74.2	16	3.82
	4	2.62	1	0.698	79.8	16	3.8
	5	2.61	1	0.697	79.7	16	3.8
	6	2.62	1	0.698	79.8	16	3.8
56	1	2.42	2	0.663	75.7	16	3.75

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	2	2.42	2	0.664	75.8	16	3.75
	3	2.42	2	0.663	75.7	16	3.75
	4	2.33	3	0.635	72.6	16	3.75
	5	2.47	2	0.638	72.9	16	3.86
	6	2.33	3	0.635	72.6	16	3.76
57	1	1.84	4	0.61	70.5	16	3.43
	2	1.84	4	0.61	70.5	16	3.43
	3	1.84	4	0.609	70.4	16	3.43
	4	1.76	4	0.577	66.7	16	3.45
	5	1.76	4	0.577	66.7	16	3.45
	6	1.75	4	0.577	66.7	16	3.44
58	1	2.03	4	0.674	77	16	3.43
	2	2.03	4	0.672	76.7	16	3.43
	3	2.03	4	0.674	77	16	3.43
	4	1.93	4	0.634	72.4	16	3.45
	5	1.92	4	0.634	72.4	16	3.44
	6	1.92	4	0.635	72.5	16	3.43
59	1	1.99	4	0.644	73.6	16	3.47
	2	1.98	4	0.644	73.6	16	3.47
	3	1.99	4	0.644	73.6	16	3.47
	4	1.94	4	0.629	71.8	16	3.47
	5	1.95	4	0.631	72	16	3.47
	6	1.95	4	0.63	71.9	16	3.47
60	1	2.27	3	0.578	66	16	3.92
	2	2.28	3	0.576	65.7	16	3.93
	3	2.28	3	0.578	66	16	3.93
	4	2.35	3	0.605	69	16	3.9
	5	2.35	3	0.605	69	16	3.9
	6	2.36	3	0.607	69.2	16	3.9
61	1	2.47	2	0.69	78.1	15.8	3.81
	2	2.46	2	0.688	77.9	15.8	3.81
	3	2.46	2	0.688	77.9	15.8	3.81
	4	2.33	3	0.652	73.8	15.8	3.8
	5	2.33	3	0.652	73.8	15.8	3.81

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	6	2.36	3	0.656	74.3	15.8	3.82
62	1	1.75	4	0.499	57	16	3.7
	3	1.75	4	0.498	56.9	16	3.7
	4	1.74	4	0.498	56.9	16	3.7
	5	1.8	4	0.514	58.7	16	3.7
	6	1.8	4	0.513	58.6	16	3.7
63	1	1.62	4	0.583	66.4	16	3.31
	2	1.63	4	0.583	66.4	16	3.31
	3	1.62	4	0.581	66.3	16	3.31
	4	1.59	4	0.575	65.6	16	3.29
	5	1.6	4	0.577	65.9	16	3.29
	6	1.6	4	0.577	65.9	16	3.29
64	1	2.2	3	0.642	73.3	16	3.66
	2	2.21	3	0.643	73.5	16	3.66
	3	2.2	3	0.641	73.2	16	3.66
	4	2.28	3	0.668	76.4	16	3.65
	5	2.29	3	0.672	76.7	16	3.65
	6	2.29	3	0.671	76.6	16	3.65
65	1	1.58	4	0.65	74.3	16	3.08
	2	1.58	4	0.649	74.2	16	3.08
	3	1.58	4	0.649	74.2	16	3.08
	4	1.47	4	0.604	69	16	3.08
	5	1.47	4	0.603	68.9	16	3.08
	6	1.47	4	0.602	68.8	16	3.08
66	1	1.87	4	0.543	62	16	3.66
	2	1.86	4	0.542	61.9	16	3.66
	3	1.86	4	0.542	61.9	16	3.66
	4	1.81	4	0.527	60.3	16	3.66
	5	1.8	4	0.525	60	16	3.66
	6	1.8	4	0.525	60	16	3.66
67	1	2.03	4	0.638	72.9	16	3.52
	2	2.03	4	0.637	72.7	16	3.53
	3	2.03	4	0.638	72.9	16	3.52

Table 6.2 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
	4	2.04	4	0.637	72.7	16	3.54
	5	2.04	4	0.636	72.6	16	3.54
	6	2.03	4	0.636	72.6	16	3.53
68	1	2.15	3	0.545	62.2	16	3.92
	2	2.16	3	0.548	62.6	16	3.92
	3	2.15	3	0.546	62.4	16	3.92
	4	1.85	4	0.467	53.4	16	3.93
	5	1.85	4	0.466	53.2	16	3.93
	6	1.84	4	0.464	53	16	3.93

APPENDIX C

MFL and MOR values of selected 82 samples

SR	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
1	37AaR	25.4	25.4	723.54	12.79	15,194.24	1,821,637.58
2	35AbM	25.4	25.4	577.94	7.11	12,136.78	1,792,798.69
3	35AbL	25.4	25.4	868.22	13	18,232.71	1,866,389.70
4	35AcR	25.4	25.4	421.7	5.93	8,855.70	1,420,019.39
5	35AcM	25.4	25.4	900.19	11.1	18,904.02	2,015,357.42
6	34BaR	25.4	25.4	900.19	12.34	18,904.02	2,254,493.94
7	35AcL	25.4	25.4	774.13	11.02	16,256.75	1,980,164.70
8	32AaL	25.4	25.4	919.72	13.9	19,314.21	2,188,501.72
9	66AbM	25.4	25.4	674.7	15.99	14,168.76	1,642,384.41
10	66AbL	25.4	25.4	5.34	0	112.04	-----
11	66AbL	25.4	25.4	784.78	15.31	16,480.37	1,709,953.65
12	66AbR	25.4	25.4	579.71	10.83	12,173.82	1,240,722.02
13	4BbL	25.4	25.4	625.87	10.31	13,143.28	1,512,460.17
14	39AcM	25.4	25.4	731.52	14.22	15,361.83	1,657,821.99
15	63BaM	25.4	25.4	424.35	10.41	8,911.26	1,438,521.13
16	54BaL	25.4	25.4	418.15	7.38	8,781.16	1,209,491.55
17	41BbL	25.4	25.4	6.22	0.43	130.56	-----
18	41BbL	25.4	25.4	679.13	12.3	14,261.81	1,566,470.22
19	63BaL	25.4	25.4	741.28	13.18	15,566.93	1,619,394.97
20	39AcL	25.4	25.4	573.49	9.21	12,043.26	1,513,158.64
21	39AcR	25.4	25.4	688.9	12.81	14,466.91	1,634,996.77
22	37AaL	25.4	25.4	848.69	13.86	17,822.52	2,002,453.17
23	37AaM	25.4	25.4	863.79	12.11	18,139.65	2,049,126.84
24	41BbM	25.4	25.4	709.32	11.1	14,895.62	1,580,547.69
25	41BbR	25.4	25.4	460.74	9.07	9,675.62	1,145,648.28
26	46AcM	25.4	25.4	680.02	7.16	14,280.33	2,190,092.91

Table 6.3: MFL and MOR samples of selected 82 samples

Table 6.3 (Cont'd)

SR	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
27	48BaM	25.4	25.4	818.51	11.68	17,188.71	2,107,911.11
28	34BaM	25.4	25.4	740.4	13.67	15,548.41	2,066,032.15
29	34BaL	25.4	25.4	795.43	12.81	16,703.98	2,019,483.10
30	54AcR	25.4	25.4	562.84	11	11,819.64	1,322,618.13
31	54AcM	25.4	25.4	545.09	8.61	11,446.95	1,386,263.26
32	14BcM	25.4	25.4	925.04	14.9	19,425.79	2,279,256.19
33	37AcL	25.4	25.4	831.83	13.26	17,468.35	1,958,755.89
34	32AaR	25.4	25.4	831.83	14.62	17,468.35	1,669,604.78
35	32AaM	25.4	25.4	781.23	9.79	16,405.83	1,988,730.03
36	6AbM	25.4	25.4	768.8	12.5	16,144.71	1,464,829.43
37	4BbR	25.4	25.4	744.83	13.02	15,641.47	1,670,498.26
38	6AbL	25.4	25.4	795.43	13.87	16,703.98	1,481,410.45
39	4BbM	25.4	25.4	694.24	12.81	14,578.95	1,619,735.76
40	4BcR	25.4	25.4	677.37	12.59	14,224.77	1,623,109.88
41	63BaR	25.4	25.4	666.7	8.88	14,000.70	1,687,831.43
42	4BcM	25.4	25.4	721.75	11.38	15,156.74	1,880,163.50
43	4BcL	25.4	25.4	774.13	15.38	16,256.75	1,809,696.76
44	46AcL	25.4	25.4	947.24	11.22	19,892.00	2,223,754.61
45	46AcR	25.4	25.4	641.85	7.17	13,478.93	1,814,996.26
46	48BaL	25.4	25.4	790.11	10.42	16,592.41	2,051,822.02
47	48BaR	25.4	25.4	721.75	11.82	15,156.74	1,894,599.97
48	54AcR	25.4	25.4	841.59	14.46	17,673.44	1,780,289.30
49	54AcL	25.4	25.4	578.82	10.86	12,155.30	1,341,018.74
50	56AaL	25.4	25.4	709.32	11.48	14,895.62	1,786,190.35
51	54AcM	25.4	25.4	647.19	14.15	13,590.97	1,336,473.79
52	38BbR	25.4	25.4	653.95	9.54	13,732.95	1,587,494.89
53	8BbR	25.4	25.4	618.52	11.38	12,988.92	1,449,163.17
54	68AaM	25.4	25.4	721.6	12	15,153.60	1,889,539.52
55	68AaR	25.4	25.4	674.89	12.4	14,172.69	1,714,466.37
56	68AaL	25.4	25.4	662	11.27	13,902.00	1,859,132.73
57	32BcR	25.4	25.4	808.74	12.25	16,983.62	1,987,273.86

Table 6.3 (Cont'd)

SR	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
58	32BcM	25.4	25.4	930.37	11.98	19,537.83	2,207,434.18
59	1BcM	25.4	25.4	743.05	9.49	15,603.96	1,856,833.98
60	32BcL	25.4	25.4	881.54	12.2	18,512.35	2,094,528.34
61	27BbR	25.4	25.4	335.59	5.94	7,047.34	1,239,332.47
62	27BbM	25.4	25.4	655.17	12.03	13,758.56	1,612,146.31
63	38BbL	25.4	25.4	670.86	11.64	14,088.06	1,561,814.25
64	60AcM	25.4	25.4	644.29	7.72	13,530.09	1,807,677.19
65	60AcL	25.4	25.4	686.97	11.78	14,426.37	1,478,893.00
66	47AaL	25.4	25.4	1,014.75	9.98	21,309.75	2,331,981.29
67	37AcR	25.4	25.4	832.74	15.18	17,487.54	1,897,098.12
68	47AaM	25.4	25.4	1,219.31	12.35	25,605.51	2,721,824.79
69	28AcL	25.4	25.4	725.63	11.75	15,238.23	1,679,727.45
70	28AcM	25.4	25.4	569.39	8.35	11,957.19	1,608,276.15
71	28AcR	25.4	25.4	744.15	10.76	15,627.15	1,679,541.52
72	37AcM	25.4	25.4	608.85	12.5	12,785.85	1,234,104.40
73	1BcL	25.4	25.4	587.11	11.91	12,329.31	1,362,055.05
74	14BcL	25.4	25.4	1,024.41	11.03	21,512.61	2,579,136.06
75	20AcM	25.4	25.4	575.03	11.42	12,075.63	1,197,952.23
76	20AcL	25.4	25.4	801.33	15.19	16,827.93	1,625,123.89
77	20AcR	25.4	25.4	547.64	14.83	11,500.44	1,204,071.96
78	56BaR	25.4	25.4	702.27	10.47	14,747.67	1,563,913.31
79	56BaM	25.4	25.4	703.88	9.98	14,781.48	1,840,825.31
80	8BbM	25.4	25.4	575.83	8.56	12,092.43	1,438,616.52
81	56BaL	25.4	25.4	695.83	9.7	14,612.43	1,911,981.80
82	8BbL	25.4	25.4	633.82	9.2	13,310.22	1,481,203.62

APPENDIX D

Visual grading of 27 samples

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
39	1	2.08	4	0.523	59.8	16	3.9	0	10.25	0	15	4	1	<1:10	1	0	8	4 screw holes (0.5" dia)	**l**	**b**	**h**	**l**	**b**	**h**	**l**	**b**	**h**
	2	2.08	4	0.524	59.9	16	3.9																				
	3	2.08	4	0.523	59.8	16	3.9																				
	4	2.13	3	0.538	61.6	16	3.89																				
	5	2.14	3	0.54	61.8	16	3.89																				
	6	2.13	3	0.538	61.6	16	3.9																				
40	1	2.1	4	0.577	65.9	16	3.74	0	0	0	12	4	1	<1:10	1	1	13	4 screw holes (0.5" dia)	0	0	0	0	0	0	10	0.5	0.5
	2	2.11	3	0.579	66.2	16	3.74																		15	0.5	0.5
	3	2.1	4	0.578	66	16	3.74																				
	4	2.23	3	0.612	70	16	3.75																				
	5	2.23	3	0.612	70	16	3.75																				
	6	2.23	3	0.613	70.1	16	3.74																				
41	1	1.93	4	0.523	59.1	15.8	3.85	0	21	0	16	0	1	<1:10	1	0	11	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	1.93	4	0.523	59.1	15.8	3.85																				
	3	1.93	4	0.523	59.1	15.8	3.85																				
	4	2.01	4	0.544	61.6	15.8	3.85																				
	5	2.01	4	0.543	61.4	15.8	3.85																				
	6	2.01	4	0.543	61.4	15.8	3.85																				
42	1	2.41	2	0.654	74.8	16	3.76	0	4.5	0	0	0	1	<1:10	1	2	11	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.43	2	0.654	74.8	16	3.78																				
	3	2.41	2	0.654	74.8	16	3.77																				
	4	2.45	2	0.667	76.2	16	3.76																				
	5	2.45	2	0.667	76.2	16	3.76																				
	6	2.44	2	0.667	76.2	16	3.76																				

Table 6.4: Visual grading of 27 samples

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
43	1	1.76	4	0.611	69.8	16	3.33	0	12.5	0	30	0	1	<1:10	1	1	6	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	1.75	4	0.609	69.5	16	3.33																				
	3	1.76	4	0.612	69.9	16	3.33																				
	4	1.84	4	0.638	72.9	16	3.33																				
	5	1.99	4	0.664	75.8	16	3.39																				
	6	1.82	4	0.634	72.4	16	3.33																				
												0	1	<1:10	1												
44	1	1.8	4	0.501	57.2	16	3.72	0	16.25	2	3					0	7	4 screw holes (0.5" dia)	0	0	0	0	0	0	3	1.5	0.5
	2	1.58	4	0.522	59.7	16	3.41																		7	1	0.5
	3	1.8	4	0.501	57.2	16	3.72																				
	4	1.91	4	0.526	60.1	16	3.74																				
	5	1.85	4	0.513	58.6	16	3.73																				
	6	1.85	4	0.513	58.6	16	3.72																				
45	1	1.87	4	0.549	62.7	16	3.63	0	13.25	0	3.5	2	1	<1:10	1	0	14	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	1.88	4	0.55	62.8	16	3.63																				
	3	1.87	4	0.548	62.6	16	3.63																				
	4	1.9	4	0.571	65.2	16	3.57																				
	5	1.82	4	0.534	61	16	3.63																				
	6	1.9	4	0.551	62.9	16	3.64																				
46	1	2.45	2	0.653	74.7	16	3.8	0	8	0	72	0	1	<1:10	1	0	9	4 screw holes (0.5" dia)	0	0	0	6	0.25	0.25	6	0.25	0.25
	2	2.46	2	0.655	74.9	16	3.8																				
	3	2.45	2	0.654	74.8	16	3.8																				
	4	2.34	3	0.627	71.6	16	3.79																				
	5	2.35	3	0.628	71.7	16	3.8																				
	6	2.42	2	0.636	72.7	16	3.83																				
47	1	2.58	2	0.695	79.4	16	3.78	0	5.25	0	12	0	1	<1:10	1	0	10	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.58	2	0.694	79.3	16	3.79																				

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
	3	2.62	1	0.706	80.7	16	3.78																				
	4	2.69	1	0.727	83	16	3.78																				
	5	2.68	1	0.726	82.9	16	3.77																				
	6	2.68	1	0.724	82.7	16	3.78																				
48	1	2.97	1	0.719	81.7	15.9	4.03	0	0	0	12	3	1	<1:10	1	4	4	4 screw holes (0.5" dia)	8	0.5	0.5	0	0	0	0	0	0
	2	2.98	1	0.718	81.6	15.9	4.04																				
	3	2.98	1	0.718	81.6	15.9	4.04																				
	4	2.87	1	0.695	79	15.9	4.03																				
	5	2.86	1	0.695	79	15.9	4.02																				
	6	2.88	1	0.695	79	15.9	4.03																				
49	1	2.48	2	0.609	69.5	16	3.96	0	20.75	0	4	5	1	<1:10	1	1	4	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.48	2	0.608	69.4	16	3.96																				
	3	2.49	2	0.611	69.8	16	3.96																				
	4	2.42	2	0.591	67.6	16	3.97																				
	5	2.42	2	0.592	67.7	16	3.97																				
	6	2.41	2	0.596	68.1	16	3.94																				
50	1	1.88	4	0.576	65.8	16	3.54	0	8.75	0	4	5	1	<1:10	1	2	6	4 screw holes (0.5" dia)	18	0.25	0.25	0	0	0	0	0	0
	2	1.88	4	0.576	65.8	16	3.55																				
	3	1.89	4	0.578	66	16	3.54																				
	4	1.78	4	0.545	62.2	16	3.54																				
	5	1.79	4	0.545	62.2	16	3.56																				
	6	1.79	4	0.547	62.4	16	3.55																				
												0	1	<1:10	1												
51	1	1.43	4	0.505	57.7	16	3.3	0	9.25	0	3					0	10	4 screw holes (0.5" dia)	0	0	0	0	0	0	9	0.5	0.5
	2	1.43	4	0.506	57.8	16	3.3																				
	3	1.43	4	0.505	57.7	16	3.3																				
	4	1.47	4	0.518	59.2	16	3.31																				
	5	1.47	4	0.519	59.3	16	3.31																				

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
	6	1.47	4	0.518	59.2	16	3.31																				
								0	7.3																		
52	1	2.1	3	0.593	67.8	16	3.69			0	6	0	1	<1:10	1	0	14	4 screw holes (0.5" dia)	64	1	1.5	0	0	0	0	0	0
	2	2.1	4	0.593	67.8	16	3.69																				
	3	2.09	4	0.591	67.6	16	3.69																				
	4	2.34	3	0.665	75.9	16	3.68																				
	5	2.35	3	0.666	76	16	3.69																				
	6	2.34	3	0.664	75.8	16	3.68																				
53	1	1.74	4	0.541	61.6	15.9	3.54	0	0	0	8	5.5	1	<1:10	1	3	9	4 screw holes (0.5" dia)	0	0	0	0	0	0	5	1.5	0.5
	2	1.75	4	0.544	62	15.9	3.54																				
	3	1.74	4	0.542	61.7	15.9	3.54																				
	4	1.7	4	0.523	59.5	15.9	3.57																				
	5	1.7	4	0.523	59.5	15.9	3.57																				
	6	1.7	4	0.523	59.5	15.9	3.56																				
54	1	1.67	4	0.654	74.1	15.8	3.19	0	0	0	45	3	1	<1:10	1	4	16	4 screw holes (0.5" dia)	1.5	0.5	0.25	0	0	0	14	0.5	0.5
	2	1.68	4	0.657	74.3	15.8	3.19																				
	3	1.67	4	0.654	74.1	15.8	3.19																				
	4	1.65	4	0.646	73.1	15.8	3.19																				
	5	1.66	4	0.648	73.4	15.8	3.2																				
	6	1.65	4	0.646	73.1	15.8	3.19																				
55	1	2.47	2	0.649	74.2	16	3.82	0	0	0	65	1.5	1	<1:10	1	2	9	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.46	2	0.649	74.2	16	3.82																				
	3	2.46	2	0.649	74.2	16	3.82																				
	4	2.62	1	0.698	79.8	16	3.8																				
	5	2.61	1	0.697	79.7	16	3.8																				
	6	2.62	1	0.698	79.8	16	3.8																				

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
56	1	2.42	2	0.663	75.7	16	3.75	0	1	0	17	5	1	<1:10	1	2	10	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.42	2	0.664	75.8	16	3.75																				
	3	2.42	2	0.663	75.7	16	3.75																				
	4	2.33	3	0.635	72.6	16	3.75																				
	5	2.47	2	0.638	72.9	16	3.86																				
	6	2.33	3	0.635	72.6	16	3.76																				
57	1	1.84	4	0.61	70.5	16	3.43	0	0	0	5	3	1	<1:10	1	1	6	4 screw holes (0.5" dia)	0	0	0	0	0	0	42	0.25	0.5
	2	1.84	4	0.61	70.5	16	3.43																		8	0.5	0.5
	3	1.84	4	0.609	70.4	16	3.43																				
	4	1.76	4	0.577	66.7	16	3.45																				
	5	1.76	4	0.577	66.7	16	3.45																				
	6	1.75	4	0.577	66.7	16	3.44																				
58	1	2.03	4	0.674	77	16	3.43	0	9.5	2.75	5	2.5	1	<1:10	1	0	7	4 screw holes (0.5" dia)	0	0	0	0	0	0	1.5	0.5	0.5
	2	2.03	4	0.672	76.7	16	3.43																				
	3	2.03	4	0.674	77	16	3.43																				
	4	1.93	4	0.634	72.4	16	3.45																				
	5	1.92	4	0.634	72.4	16	3.44																				
	6	1.92	4	0.635	72.5	16	3.43																				
59	1	1.99	4	0.644	73.6	16	3.47	0	4.5	0	17	2.5	1	<1:10	1	0	7	4 screw holes (0.5" dia)	0	0	0	2	0.5	0.5	0	0	0
	2	1.98	4	0.644	73.6	16	3.47																				
	3	1.99	4	0.644	73.6	16	3.47																				
	4	1.94	4	0.629	71.8	16	3.47																				
	5	1.95	4	0.631	72	16	3.47																				
	6	1.95	4	0.63	71.9	16	3.47																				
60	1	2.27	3	0.578	66	16	3.92	0	8	0	70	4	1	<1:10	1	6	13	4 screw holes (0.5" dia)	0	0	0	0	0	0	3	0.5	0.75
	2	2.28	3	0.576	65.7	16	3.93																		10	1	1

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
	3	2.28	3	0.578	66	16	3.93																				
	4	2.35	3	0.605	69	16	3.9																				
	5	2.35	3	0.605	69	16	3.9																				
	6	2.36	3	0.607	69.2	16	3.9																				
												0	1	<1:10	1												
61	1	2.47	2	0.69	78.1	15.8	3.81	0	4.25	0	84					3	8	4 screw holes (0.5" dia)	0	0	0	3	1.5	0.25	0	0	0
	2	2.46	2	0.688	77.9	15.8	3.81																				
	3	2.46	2	0.688	77.9	15.8	3.81																				
	4	2.33	3	0.652	73.8	15.8	3.8																				
	5	2.33	3	0.652	73.8	15.8	3.81																				
	6	2.36	3	0.656	74.3	15.8	3.82																				
62	1	1.75	4	0.499	57	16	3.7	0	13.2	0	1.5	0	1	<1:10	1	2	8	4 screw holes (0.5" dia)	0	0	0	0	0	0	13.5	1.5	0.75
	3	1.75	4	0.498	56.9	16	3.7																		19	0.75	0.25
	4	1.74	4	0.498	56.9	16	3.7																		5	0.25	0.25
	5	1.8	4	0.514	58.7	16	3.7																		4	0.3	0.5
	6	1.8	4	0.513	58.6	16	3.7																				
63	1	1.62	4	0.583	66.4	16	3.31	0	11	0	0	10	1	<1:10	1	2	8	4 screw holes (0.5" dia)	0	0	0	0	0	0	6	0.5	0.5
	2	1.63	4	0.583	66.4	16	3.31																				
	3	1.62	4	0.581	66.3	16	3.31																				
	4	1.59	4	0.575	65.6	16	3.29																				
	5	1.6	4	0.577	65.9	16	3.29																				
	6	1.6	4	0.577	65.9	16	3.29																				
65	1	1.58	4	0.65	74.3	16	3.08	0	19.25	0	0	0	1	<1:10	1	4	7	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0

Table 6.4 (Cont'd)

Sample Number	Run Number	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]	KNOTS			SHAKE/ CHECK (in.)	END SPLIT (in.)	Grade	SLOPE OF GRAIN	Grade	NAIL HOLES (1/8 in.)			DAMAGE								
								Narrow face (in.)	Wide face Centerline (in.)	Wide face Edge (in.)						Narrow face	Wide face Center line	Wide face Edge	Narrow face (in.)			Wide face Centerline (in.)			Wide face Edge (in.)		
	2	1.58	4	0.649	74.2	16	3.08																				
	3	1.58	4	0.649	74.2	16	3.08																				
	4	1.47	4	0.604	69	16	3.08																				
	5	1.47	4	0.603	68.9	16	3.08																				
	6	1.47	4	0.602	68.8	16	3.08																				
67	1	2.03	4	0.638	72.9	16	3.52	0	0.5	0	0	0	1	<1:10	1	0	4	4 screw holes (0.5" dia)	0	0	0	0	0	0	0	0	0
	2	2.03	4	0.637	72.7	16	3.53																				
	3	2.03	4	0.638	72.9	16	3.52																				
	4	2.04	4	0.637	72.7	16	3.54																				
	5	2.04	4	0.636	72.6	16	3.54																				
	6	2.03	4	0.636	72.6	16	3.53																				

APPENDIX E

MOE values of salvaged samples from Metriguard

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
1	1	2.18	3	0.548	10	8
	2	2.16	3	0.548	10	8
	3	2.17	3	0.548	10	8
	4	2.16	3	0.541	9.8	8
	5	2.15	3	0.539	9.8	8
	6	2.15	3	0.539	9.8	8
2	1	2.13	3	0.535	9.7	8
	2	2.14	3	0.534	9.7	8
	3	2.14	3	0.534	9.7	8
	4	2.17	3	0.542	9.8	8
	5	2.18	3	0.542	9.8	8
	6	2.18	3	0.542	9.8	8
3	1	1.77	4	0.511	9.3	8
	2	1.77	4	0.51	9.3	8
	3	1.78	4	0.511	9.3	8
	4	1.87	4	0.532	9.7	8
	5	1.86	4	0.53	9.6	8
	6	1.87	4	0.53	9.6	8
4	1	2.16	3	0.573	10.4	8
	2	2.16	3	0.573	10.4	8
	3	2.16	3	0.573	10.4	8
	4	2.09	4	0.558	10.1	8
	5	2.09	4	0.558	10.1	8
	6	2.08	4	0.56	10.2	8
5	1	2.2	3	0.6	10.9	8
	2	2.19	3	0.601	10.9	8
	3	2.21	3	0.601	10.9	8
	4	2.07	4	0.56	10.2	8
	5	2.07	4	0.558	10.1	8
	6	2.07	4	0.558	10.1	8
6	1	2.2	3	0.557	10.1	8
	2	2.21	3	0.558	10.1	8
	3	2.21	3	0.557	10.1	8
	4	2.13	3	0.533	9.7	8
	5	2.14	3	0.534	9.7	8
	6	2.13	3	0.533	9.7	8

Table 6.5 MOE values of salvaged samples from Metriguard

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
7	1	2.62	1	0.679	12.3	8
	2	2.61	1	0.679	12.3	8
	3	2.62	1	0.678	12.3	8
	4	2.68	1	0.697	12.7	8
	5	2.67	1	0.697	12.7	8
	6	2.67	1	0.697	12.7	8
8	1	2.71	1	0.707	12.8	8
	2	2.7	1	0.707	12.8	8
	3	2.69	1	0.707	12.8	8
	4	2.7	1	0.693	12.6	8
	5	2.67	1	0.691	12.6	8
	6	2.69	1	0.691	12.6	8
9	1	2.96	1	0.7	12.7	8
	2	2.96	1	0.702	12.8	8
	3	2.97	1	0.702	12.8	8
	4	2.98	1	0.697	12.7	8
	5	2.99	1	0.695	12.6	8
	6	2.99	1	0.697	12.7	8
10	1	2.41	2	0.69	12.5	8
	2	2.43	2	0.691	12.6	8
	3	2.42	2	0.691	12.6	8
	4	2.45	2	0.694	12.6	8
	5	2.45	2	0.694	12.6	8
	6	2.46	2	0.695	12.6	8
11	1	2.41	2	0.747	13.6	8
	2	2.41	2	0.746	13.6	8
	3	2.4	2	0.746	13.6	8
	4	2.27	3	0.707	12.8	8
	5	2.28	3	0.707	12.8	8
	6	2.29	3	0.707	12.8	8
12	1	2.88	1	0.811	14.7	8
	2	2.89	1	0.812	14.8	8
	3	2.89	1	0.812	14.8	8
	4	2.69	1	0.761	13.8	8
	5	2.68	1	0.759	13.8	8
	6	2.7	1	0.761	13.8	8
13	1	2.18	3	0.613	11.1	8
	2	2.2	3	0.614	11.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.2	3	0.614	11.2	8
	4	2.25	3	0.626	11.4	8
	5	2.25	3	0.624	11.3	8
	6	2.23	3	0.624	11.3	8
14	1	2.35	3	0.639	11.6	8
	2	2.34	3	0.639	11.6	8
	3	2.35	3	0.641	11.6	8
	4	2.36	3	0.638	11.6	8
	5	2.38	3	0.639	11.6	8
	6	2.38	3	0.641	11.6	8
15	1	2.51	2	0.628	11.4	8
	2	2.51	2	0.628	11.4	8
	3	2.51	2	0.628	11.4	8
	4	2.41	2	0.603	11	8
	5	2.4	2	0.601	10.9	8
	6	2.39	3	0.601	10.9	8
16	1	1.45	4	0.629	11.4	8
	2	1.44	4	0.629	11.4	8
	3	1.44	4	0.629	11.4	8
	4	1.44	4	0.627	11.4	8
	5	1.44	4	0.627	11.4	8
	6	1.44	4	0.627	11.4	8
17	1	2.58	2	0.627	11.4	8
	2	2.6	2	0.628	11.4	8
	3	2.58	2	0.628	11.4	8
	4	2.66	1	0.642	11.7	8
	5	2.65	1	0.639	11.6	8
	6	2.65	1	0.641	11.6	8
18	1	1.81	4	0.48	8.7	8
	2	1.81	4	0.48	8.7	8
	3	1.82	4	0.48	8.7	8
	4	1.92	4	0.504	9.2	8
	5	1.92	4	0.504	9.2	8
	6	1.92	4	0.502	9.1	8
19	1	1.87	4	0.511	9.3	8
	2	1.87	4	0.51	9.3	8
	3	1.87	4	0.51	9.3	8
	4	1.82	4	0.495	9	8
	5	1.81	4	0.495	9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.82	4	0.495	9	8
20	1	1.65	4	0.495	9	8
	2	1.64	4	0.494	9	8
	3	1.65	4	0.495	9	8
	4	1.64	4	0.487	8.9	8
	5	1.63	4	0.487	8.9	8
	6	1.64	4	0.487	8.9	8
21	1	2.22	3	0.527	9.6	8
	2	2.21	3	0.528	9.6	8
	3	2.22	3	0.528	9.6	8
	4	2.24	3	0.535	9.7	8
	5	2.26	3	0.535	9.7	8
	6	2.25	3	0.534	9.7	8
22	1	2.01	4	0.51	9.3	8
	2	2.01	4	0.51	9.3	8
	3	2.01	4	0.51	9.3	8
	4	2.05	4	0.52	9.5	8
	5	2.06	4	0.52	9.5	8
	6	2.04	4	0.52	9.5	8
23	1	2.06	4	0.533	9.7	8
	2	2.06	4	0.533	9.7	8
	3	2.06	4	0.533	9.7	8
	4	2.13	3	0.549	10	8
	5	2.14	3	0.551	10	8
	6	2.13	3	0.551	10	8
24	1	2.19	3	0.559	10.1	8
	2	2.19	3	0.559	10.1	8
	3	2.19	3	0.559	10.1	8
	4	2.13	3	0.548	9.9	8
	5	2.13	3	0.546	9.9	8
	6	2.13	3	0.546	9.9	8
25	1	2.29	3	0.565	10.3	8
	2	2.29	3	0.565	10.3	8
	3	2.29	3	0.565	10.3	8
	4	2.32	3	0.575	10.4	8
	5	2.32	3	0.574	10.4	8
	6	2.32	3	0.574	10.4	8
26	1	2.33	3	0.546	9.9	8
	2	2.33	3	0.545	9.9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.34	3	0.545	9.9	8
	4	2.32	3	0.545	9.9	8
	5	2.32	3	0.546	9.9	8
	6	2.33	3	0.546	9.9	8
27	1	2.28	3	0.572	10.4	8
	2	2.29	3	0.573	10.4	8
	3	2.29	3	0.573	10.4	8
	4	2.3	3	0.574	10.4	8
	5	2.3	3	0.574	10.4	8
	6	2.3	3	0.573	10.4	8
28	1	2.34	3	0.613	11.1	8
	2	2.34	3	0.615	11.2	8
	3	2.35	3	0.615	11.2	8
	4	2.37	3	0.69	12.5	8
	5	2.36	3	0.616	11.2	8
	6	2.36	3	0.616	11.2	8
29	1	1.93	4	0.61	11.1	8
	2	1.93	4	0.61	11.1	8
	3	1.94	4	0.611	11.1	8
	4	1.91	4	0.608	11	8
	5	1.94	4	0.611	11.1	8
	6	1.93	4	0.61	11.1	8
30	1	1.97	4	0.589	10.7	8
	2	1.97	4	0.59	10.7	8
	3	1.98	4	0.59	10.7	8
	4	2.06	4	0.609	11.1	8
	5	2.06	4	0.608	11	8
	6	2.05	4	0.608	11	8
31	1	1.77	4	0.625	11.4	8
	2	1.77	4	0.624	11.3	8
	3	1.77	4	0.625	11.4	8
	4	1.87	4	0.662	12	8
	5	1.87	4	0.663	12.1	8
	6	1.87	4	0.663	12.1	8
32	1	1.96	4	0.579	10.5	8
	2	1.97	4	0.581	10.6	8
	3	1.96	4	0.58	10.5	8
	4	1.96	4	0.58	10.5	8
	5	1.97	4	0.582	10.6	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.96	4	0.581	10.6	8
33	1	2.01	4	0.546	9.8	7.9
	2	2.02	4	0.545	9.8	7.9
	3	2.02	4	0.545	9.8	7.9
	4	2.01	4	0.545	9.8	7.9
	5	2.02	4	0.545	9.8	7.9
	6	2.02	4	0.545	9.8	7.9
34	1	1.75	4	0.593	10.8	8
	2	1.75	4	0.593	10.8	8
	3	1.75	4	0.593	10.8	8
	4	1.78	4	0.601	10.9	8
	5	1.78	4	0.6	10.9	8
	6	1.79	4	0.601	10.9	8
35	1	2.12	3	0.55	10	8
	2	2.13	3	0.551	10	8
	3	2.13	3	0.55	10	8
	4	2.16	3	0.562	10.2	8
	5	2.17	3	0.563	10.2	8
	6	2.17	3	0.563	10.2	8
36	1	1.58	4	0.556	10.1	8
	2	1.57	4	0.556	10.1	8
	3	1.57	4	0.556	10.1	8
	4	1.47	4	0.516	9.3	8
	5	1.48	4	0.517	9.4	8
	6	1.47	4	0.517	9.4	8
37	1	1.45	4	0.531	9.6	8
	2	1.44	4	0.53	9.6	8
	3	1.46	4	0.531	9.6	8
	4	1.45	4	0.532	9.7	8
	5	1.45	4	0.531	9.6	8
	6	1.46	4	0.531	9.6	8
38	1	1.65	4	0.531	9.6	8
	2	1.65	4	0.531	9.6	8
	3	1.65	4	0.531	9.6	8
	4	1.63	4	0.521	9.5	8
	5	1.63	4	0.521	9.5	8
	6	1.62	4	0.521	9.5	8
39	1	1.19	4	0.492	8.9	8
	2	1.19	4	0.492	8.9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.19	4	0.492	8.9	8
	4	1.15	4	0.478	8.7	8
	5	1.15	4	0.477	8.7	8
	6	1.15	4	0.477	8.7	8
40	1	1.29	4	0.565	10.3	8
	2	1.28	4	0.565	10.3	8
	3	1.29	4	0.565	10.3	8
	4	1.26	4	0.551	10	8
	5	1.27	4	0.553	10.1	8
	6	1.26	4	0.551	10	8
41	1	1.73	4	0.546	9.9	8
	2	1.74	4	0.548	10	8
	3	1.74	4	0.546	9.9	8
	4	1.58	4	0.502	9.1	8
	5	1.58	4	0.501	9.1	8
	6	1.57	4	0.501	9.1	8
42	1	1.8	4	0.538	9.8	8
	2	1.8	4	0.538	9.8	8
	3	1.81	4	0.538	9.8	8
	4	1.78	4	0.528	9.6	8
	5	1.77	4	0.528	9.6	8
	6	1.8	4	0.53	9.6	8
43	1	2.04	4	0.553	10	8
	2	2.04	4	0.552	10	8
	3	2.04	4	0.552	10	8
	4	2.03	4	0.551	10	8
	5	2.03	4	0.551	10	8
	6	2.04	4	0.552	10	8
44	1	2.27	3	0.563	10.2	8
	2	2.28	3	0.563	10.2	8
	3	2.27	3	0.563	10.2	8
	4	2.27	3	0.565	10.2	8
	5	2.27	3	0.563	10.2	8
	6	2.26	3	0.563	10.2	8
45	1	2.5	2	0.576	10.3	7.9
	2	2.52	2	0.576	10.3	7.9
	3	2.52	2	0.574	10.3	7.9
	4	2.38	3	0.551	9.8	7.9
	5	2.4	2	0.552	9.9	7.9

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.39	3	0.552	9.9	7.9
46	1	2.4	3	0.569	10.2	7.9
	2	2.42	2	0.57	10.2	7.9
	3	2.4	3	0.57	10.2	7.9
	4	2.33	3	0.56	10	7.9
	5	2.33	3	0.56	10	7.9
	6	2.31	3	0.559	10	7.9
47	1	2.04	4	0.56	10	7.9
	2	2.04	4	0.56	10	7.9
	3	2.04	4	0.56	10	7.9
	4	2.09	4	0.55	9.8	7.9
	5	2.1	3	0.549	9.8	7.9
	6	2.11	3	0.549	9.8	7.9
48	1	2.64	1	0.64	11.6	8
	2	2.68	1	0.643	11.7	8
	3	2.67	1	0.641	11.7	8
	4	2.69	1	0.648	11.8	8
	5	2.69	1	0.648	11.8	8
	6	2.69	1	0.648	11.8	8
49	1	2.48	2	0.666	12.1	8
	2	2.48	2	0.666	12.1	8
	3	2.47	2	0.666	12.1	8
	4	2.36	3	0.631	11.5	8
	5	2.37	3	0.632	11.5	8
	6	2.37	3	0.632	11.5	8
50	1	2.75	1	0.655	11.9	8
	2	2.72	1	0.653	11.9	8
	3	2.74	1	0.655	11.9	8
	4	2.75	1	0.653	11.9	8
	5	2.74	1	0.652	11.9	8
	6	2.75	1	0.652	11.9	8
51	1	2.81	1	0.6	10.9	8
	2	2.81	1	0.598	10.9	8
	3	2.79	1	0.6	10.9	8
	4	2.84	1	0.612	11.1	8
	5	2.85	1	0.612	11.1	8
	6	2.85	1	0.612	11.1	8
52	1	2.62	1	0.587	10.7	8
	2	2.62	1	0.587	10.7	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.6	1	0.586	10.7	8
	4	2.67	1	0.607	11	8
	5	2.68	1	0.607	11	8
	6	2.68	1	0.607	11	8
53	1	2.74	1	0.616	11.2	8
	2	2.75	1	0.616	11.2	8
	3	2.76	1	0.619	11.3	8
	4	2.82	1	0.631	11.5	8
	5	2.8	1	0.629	11.4	8
	6	2.81	1	0.63	11.5	8
54	1	1.88	4	0.516	9.4	8
	2	1.88	4	0.516	9.4	8
	3	1.87	4	0.516	9.4	8
	4	1.89	4	0.522	9.5	8
	5	1.91	4	0.522	9.5	8
	6	1.91	4	0.521	9.5	8
55	1	1.73	4	0.52	9.4	8
	2	1.73	4	0.521	9.5	8
	3	1.73	4	0.521	9.5	8
	4	1.73	4	0.521	9.5	8
	5	1.73	4	0.521	9.5	8
	6	1.72	4	0.52	9.4	8
56	1	1.82	4	0.532	9.7	8
	2	1.82	4	0.532	9.7	8
	3	1.8	4	0.531	9.6	8
	4	1.81	4	0.531	9.6	8
	5	1.82	4	0.532	9.7	8
	6	1.82	4	0.532	9.7	8
57	1	1.88	4	0.511	9.1	7.9
	2	1.88	4	0.511	9.1	7.9
	3	1.89	4	0.512	9.2	7.9
	4	1.86	4	0.51	9.1	7.9
	5	1.87	4	0.511	9.1	7.9
	6	1.87	4	0.511	9.1	7.9
58	1	1.79	4	0.52	9.3	7.9
	2	1.8	4	0.52	9.3	7.9
	3	1.8	4	0.52	9.3	7.9
	4	1.75	4	0.568	10.1	7.9
	5	1.79	4	0.52	9.3	7.9

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.8	4	0.52	9.3	7.9
59	1	1.71	4	0.538	9.6	7.9
	2	1.71	4	0.538	9.6	7.9
	3	1.71	4	0.539	9.6	7.9
	4	1.79	4	0.541	9.7	7.9
	5	1.8	4	0.543	9.7	7.9
	6	1.81	4	0.543	9.7	7.9
60	1	1.22	4	0.539	9.8	8
	2	1.22	4	0.537	9.8	8
	3	1.22	4	0.537	9.8	8
	4	1.22	4	0.539	9.8	8
	5	1.22	4	0.537	9.8	8
	6	1.22	4	0.537	9.8	8
61	1	1.42	4	0.541	9.8	8
	2	1.42	4	0.541	9.8	8
	3	1.42	4	0.542	9.8	8
	4	1.41	4	0.541	9.8	8
	5	1.42	4	0.542	9.8	8
	6	1.41	4	0.541	9.8	8
62	1	1.44	4	0.53	9.6	8
	2	1.44	4	0.53	9.6	8
	3	1.44	4	0.532	9.7	8
	4	1.45	4	0.533	9.7	8
	5	1.45	4	0.533	9.7	8
	6	1.45	4	0.533	9.7	8
63	1	1.19	4	0.511	9.3	8
	2	1.19	4	0.513	9.3	8
	3	1.2	4	0.511	9.3	8
	4	1.18	4	0.501	9.1	8
	5	1.18	4	0.5	9.1	8
	6	1.17	4	0.5	9.1	8
64	1	1.66	4	0.523	9.5	8
	2	1.65	4	0.521	9.5	8
	3	1.66	4	0.523	9.5	8
	4	1.71	4	0.529	9.6	8
	5	1.71	4	0.529	9.6	8
	6	1.71	4	0.529	9.6	8
65	1	2.23	3	0.548	10	8
	2	2.22	3	0.549	10	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.22	3	0.548	10	8
	4	2.11	3	0.515	9.4	8
	5	2.11	3	0.518	9.4	8
	6	2.11	3	0.515	9.4	8
66	1	2.58	2	0.579	10.5	8
	2	2.6	2	0.579	10.5	8
	3	2.58	2	0.579	10.5	8
	4	2.52	2	0.571	10.4	8
	5	2.51	2	0.571	10.4	8
	6	2.53	2	0.572	10.4	8
67	1	2.25	3	0.56	10.2	8
	2	2.25	3	0.558	10.1	8
	3	2.25	3	0.558	10.1	8
	4	2.25	3	0.552	10	8
	5	2.24	3	0.551	10	8
	6	2.25	3	0.552	10	8
68	1	1.64	4	0.53	9.6	8
	2	1.65	4	0.532	9.7	8
	3	1.64	4	0.53	9.6	8
	4	1.58	4	0.513	9.3	8
	5	1.59	4	0.514	9.3	8
	6	1.59	4	0.514	9.3	8
69	1	1.49	4	0.534	9.7	8
	2	1.5	4	0.534	9.7	8
	3	1.5	4	0.534	9.7	8
	4	1.52	4	0.537	9.8	8
	5	1.53	4	0.538	9.8	8
	6	1.52	4	0.538	9.8	8
70	1	1.43	4	0.483	8.8	8
	2	1.42	4	0.483	8.8	8
	3	1.43	4	0.485	8.8	8
	4	1.45	4	0.485	8.8	8
	5	1.44	4	0.485	8.8	8
	6	1.45	4	0.483	8.8	8
71	1	2.49	2	0.639	11.6	8
	2	2.48	2	0.639	11.6	8
	3	2.5	2	0.641	11.6	8
	4	2.39	3	0.614	11.2	8
	5	2.38	3	0.614	11.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.38	3	0.613	11.1	8
72	1	2.11	3	0.593	10.8	8
	2	2.13	3	0.595	10.8	8
	3	2.12	3	0.595	10.8	8
	4	2.11	3	0.59	10.7	8
	5	2.12	3	0.591	10.7	8
	6	2.12	3	0.591	10.7	8
73	1	2.19	3	0.593	10.8	8
	2	2.21	3	0.593	10.8	8
	3	2.2	3	0.591	10.7	8
	4	2.12	3	0.57	10.4	8
	5	2.11	3	0.57	10.4	8
	6	2.13	3	0.57	10.4	8
74	4	2.11	3	0.59	10.7	8
	5	2.12	3	0.591	10.7	8
	6	2.12	3	0.591	10.7	8
	1	2.19	3	0.593	10.8	8
	2	2.21	3	0.593	10.8	8
	3	2.2	3	0.591	10.7	8
75	1	2.7	1	0.647	11.8	8
	2	2.69	1	0.646	11.7	8
	3	2.71	1	0.646	11.7	8
	4	2.83	1	0.679	12.3	8
	5	2.82	1	0.679	12.3	8
	6	2.81	1	0.678	12.3	8
76	2	1.82	4	0.614	11.2	8
	3	1.8	4	0.614	11.2	8
	4	1.83	4	0.659	12	8
	5	1.94	4	0.66	12	8
	6	1.93	4	0.657	11.9	8
	1	2.24	3	0.684	12.4	8
77	2	2.24	3	0.684	12.4	8
	3	2.24	3	0.683	12.4	8
	4	2.2	3	0.676	12.3	8
	5	2.21	3	0.676	12.3	8
	6	2.19	3	0.675	12.3	8
	1	3.18	1	0.726	13.2	8
78	2	3.18	1	0.726	13.2	8
	3	3.2	1	0.727	13.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	4	3.13	1	0.713	13	8
	5	3.13	1	0.713	13	8
	6	3.14	1	0.712	12.9	8
79	1	2.7	1	0.695	12.6	8
	2	2.71	1	0.697	12.7	8
	3	2.71	1	0.697	12.7	8
	4	2.79	1	0.716	13	8
	5	2.78	1	0.716	13	8
	6	2.79	1	0.714	13	8
80	1	2.49	2	0.643	11.7	8
	2	2.48	2	0.643	11.7	8
	3	2.49	2	0.642	11.7	8
	4	2.52	2	0.659	12	8
	5	2.53	2	0.657	11.9	8
	6	2.52	2	0.657	11.9	8
81	1	2.72	1	0.622	11.3	8
	2	2.74	1	0.623	11.3	8
	3	2.74	1	0.623	11.3	8
	4	2.74	1	0.624	11.3	8
	5	2.74	1	0.624	11.3	8
	6	2.76	1	0.627	11.4	8
82	1	3.03	1	0.67	12.2	8
	2	3.03	1	0.669	12.2	8
	3	3.02	1	0.669	12.2	8
	4	3.06	1	0.676	12.3	8
	5	3.06	1	0.678	12.3	8
	6	3.06	1	0.676	12.3	8
83	1	2.96	1	0.652	11.9	8
	2	2.97	1	0.653	11.9	8
	3	2.95	1	0.653	11.9	8
	4	3.04	1	0.679	12.3	8
	5	3.06	1	0.679	12.3	8
	6	3.06	1	0.679	12.3	8
84	1	2.75	1	0.611	11.1	8
	2	2.73	1	0.611	11.1	8
	3	2.73	1	0.611	11.1	8
	4	2.75	1	0.611	11.1	8
	5	2.75	1	0.611	11.1	8
	6	2.75	1	0.61	11.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	1	2.61	1	0.63	11.4	8
	2	2.61	1	0.63	11.4	8
	3	2.59	2	0.63	11.4	8
85	4	2.6	1	0.629	11.4	8
	5	2.61	1	0.63	11.4	8
	6	2.62	1	0.63	11.4	8
	1	3.15	1	0.669	12.2	8
	2	3.16	1	0.67	12.2	8
	3	3.15	1	0.67	12.2	8
86	4	3.19	1	0.75	13.6	8
	5	3.15	1	0.669	12.2	8
	6	3.16	1	0.67	12.2	8
	1	2.78	1	0.603	11	8
	2	2.8	1	0.601	10.9	8
	3	2.83	1	0.601	10.9	8
87	4	2.66	1	0.575	10.4	8
	5	2.64	1	0.573	10.4	8
	6	2.65	1	0.573	10.4	8
	1	2.47	2	0.567	10.3	8
	2	2.47	2	0.567	10.3	8
	3	2.45	2	0.567	10.3	8
88	4	2.38	3	0.551	10	8
	5	2.38	3	0.551	10	8
	6	2.38	3	0.549	10	8
	1	2.01	4	0.577	10.5	8
	2	2	4	0.576	10.5	8
	3	2.01	4	0.576	10.5	8
89	4	1.99	4	0.57	10.4	8
	5	1.98	4	0.568	10.3	8
	6	1.98	4	0.568	10.3	8
	1	2.01	4	0.518	9.4	8
	2	2.01	4	0.518	9.4	8
	3	2.02	4	0.518	9.4	8
90	4	1.92	4	0.504	9.2	8
	5	1.92	4	0.504	9.2	8
	6	1.92	4	0.504	9.2	8
	1	1.93	4	0.529	9.6	8
91	2	1.94	4	0.53	9.6	8
	3	1.94	4	0.53	9.6	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	GRADE	SG	Weight [lbs]	Length [ft]
	4	1.91	4	0.518	9.4	8
	5	1.91	4	0.518	9.4	8
	6	1.9	4	0.518	9.4	8
92	1	2.12	3	0.558	10.1	8
	2	2.12	3	0.558	10.1	8
	3	2.12	3	0.558	10.1	8
	4	2.08	4	0.549	10	8
	5	2.08	4	0.549	10	8
	6	2.09	4	0.549	10	8
93	1	2.15	3	0.557	10.1	8
	2	2.16	3	0.558	10.1	8
	3	2.15	3	0.558	10.1	8
	4	2.08	4	0.537	9.8	8
	5	2.07	4	0.537	9.8	8
	6	2.08	4	0.538	9.8	8
94	1	1.22	4	0.506	9.2	8
	2	1.23	4	0.506	9.2	8
	3	1.22	4	0.506	9.2	8
	4	1.24	4	0.514	9.3	8
	5	1.24	4	0.513	9.3	8
	6	1.24	4	0.513	9.3	8
95	1	1.2	4	0.542	9.8	8
	2	1.2	4	0.539	9.8	8
	3	1.2	4	0.541	9.8	8
	4	1.22	4	0.548	10	8
	5	1.21	4	0.547	9.9	8
	6	1.21	4	0.547	9.9	8
96	1	1.25	4	0.505	9.2	8
	2	1.25	4	0.505	9.2	8
	3	1.24	4	0.504	9.2	8
	4	1.29	4	0.52	9.5	8
	5	1.29	4	0.519	9.4	8
	6	1.29	4	0.519	9.4	8
97	1	1.82	4	0.481	8.7	8
	2	1.82	4	0.481	8.7	8
	3	1.82	4	0.481	8.7	8
	4	1.87	4	0.496	9	8
	5	1.87	4	0.496	9	8
	6	1.86	4	0.496	9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	1	1.72	4	0.514	9.3	8
98	2	1.72	4	0.514	9.3	8
	3	1.71	4	0.514	9.3	8
	4	1.79	4	0.519	9.4	8
	5	1.78	4	0.519	9.4	8
	6	1.79	4	0.519	9.4	8
	1	1.97	4	0.513	9.3	8
99	2	1.98	4	0.513	9.3	8
	3	1.97	4	0.513	9.3	8
	4	1.97	4	0.519	9.4	8
	5	1.97	4	0.519	9.4	8
	6	1.97	4	0.519	9.4	8
	1	2.27	3	0.575	10.4	8
100	2	2.29	3	0.575	10.4	8
	3	2.29	3	0.575	10.4	8
	4	2.37	3	0.579	10.5	8
	5	2.36	3	0.579	10.5	8
	6	2.35	3	0.579	10.5	8
	1	2.36	3	0.595	10.8	8
101	2	2.36	3	0.594	10.8	8
	3	2.36	3	0.595	10.8	8
	4	2.39	3	0.603	11	8
	5	2.4	3	0.604	11	8
	6	2.4	3	0.604	11	8
	1	2.43	2	0.59	10.7	8
102	2	2.44	2	0.593	10.8	8
	3	2.41	2	0.591	10.7	8
	4	2.44	2	0.591	10.7	8
	5	2.44	2	0.591	10.7	8
	6	2.43	2	0.59	10.7	8
	1	1.96	4	0.598	10.9	8
103	2	1.95	4	0.598	10.9	8
	3	1.95	4	0.596	10.8	8
	4	2	4	0.596	10.8	8
	5	2	4	0.596	10.8	8
	6	1.99	4	0.596	10.8	8
	1	1.83	4	0.595	10.8	8
104	2	1.83	4	0.594	10.8	8
	3	1.84	4	0.595	10.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	4	1.84	4	0.595	10.8	8
	5	1.84	4	0.595	10.8	8
	6	1.85	4	0.594	10.8	8
	1	1.94	4	0.591	10.7	8
105	2	1.95	4	0.591	10.7	8
	3	1.94	4	0.591	10.7	8
	4	2.74	1	0.609	11.1	8
	5	1.96	4	0.586	10.7	8
	6	1.95	4	0.586	10.7	8
	7	1.97	4	0.585	10.6	8
106	1	2.21	3	0.562	10.2	8
	2	2.2	3	0.562	10.2	8
	3	2.21	3	0.563	10.2	8
	4	2.31	3	0.59	10.7	8
	5	2.29	3	0.589	10.7	8
	6	2.32	3	0.59	10.7	8
107	1	2.39	3	0.601	10.9	8
	2	2.4	2	0.603	11	8
	3	2.4	3	0.601	10.9	8
	4	2.53	2	0.636	11.6	8
	5	2.51	2	0.636	11.6	8
	6	2.53	2	0.634	11.5	8
108	1	2.39	3	0.568	10.3	8
	2	2.39	3	0.568	10.3	8
	3	2.39	3	0.568	10.3	8
	4	2.44	2	0.585	10.6	8
	5	2.46	2	0.585	10.6	8
	6	2.46	2	0.585	10.6	8
109	1	2.5	2	0.535	9.7	8
	2	2.49	2	0.534	9.7	8
	3	2.5	2	0.534	9.7	8
	4	2.5	2	0.535	9.7	8
	5	2.5	2	0.535	9.7	8
	6	2.5	2	0.535	9.7	8
110	1	2.44	2	0.561	10.2	8
	2	2.44	2	0.561	10.2	8
	3	2.46	2	0.562	10.2	8
	4	2.48	2	0.562	10.2	8
	5	2.49	2	0.563	10.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.48	2	0.562	10.2	8
111	1	2.06	4	0.532	9.7	8
	2	2.06	4	0.529	9.6	8
	3	2.07	4	0.53	9.6	8
	4	2.07	4	0.538	9.8	8
	5	2.1	4	0.541	9.8	8
	6	2.1	3	0.541	9.8	8
112	1	1.93	4	0.599	10.9	8
	2	1.93	4	0.598	10.9	8
	3	1.93	4	0.598	10.9	8
	4	1.94	4	0.596	10.8	8
	5	1.95	4	0.596	10.8	8
	6	1.94	4	0.595	10.8	8
113	1	1.74	4	0.601	10.9	8
	2	1.74	4	0.601	10.9	8
	3	1.74	4	0.599	10.8	8
	4	1.68	4	0.635	11.5	8
	5	1.74	4	0.599	10.8	8
	6	1.74	4	0.599	10.8	8
114	1	1.76	4	0.601	10.9	8
	2	1.76	4	0.601	10.9	8
	3	1.77	4	0.602	10.9	8
	4	1.7	4	0.606	11	8
	5	1.7	4	0.607	11	8
	6	1.71	4	0.608	11	8
115	1	2.58	2	0.608	11.1	8
	2	2.58	2	0.607	11	8
	3	2.58	2	0.607	11	8
	4	2.51	2	0.613	11.2	8
	5	2.51	2	0.613	11.2	8
	6	2.49	2	0.613	11.2	8
116	1	2.44	2	0.601	10.9	8
	2	2.43	2	0.601	10.9	8
	3	2.44	2	0.601	10.9	8
	4	2.38	3	0.601	10.9	8
	5	2.39	3	0.601	10.9	8
	6	2.37	3	0.601	10.9	8
117	1	2.43	2	0.596	10.7	7.9
	2	2.44	2	0.595	10.7	7.9

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.42	2	0.594	10.6	7.9
	4	2.43	2	0.595	10.7	7.9
	5	2.42	2	0.594	10.6	7.9
	6	2.43	2	0.594	10.6	7.9
118	1	2.11	3	0.631	11.5	8
	2	2.11	3	0.631	11.5	8
	3	2.12	3	0.632	11.5	8
	4	1.98	4	0.593	10.8	8
	5	2	4	0.595	10.8	8
	6	2	4	0.595	10.8	8
119	1	1.61	4	0.618	11.2	8
	2	1.61	4	0.618	11.2	8
	3	1.61	4	0.618	11.2	8
	4	1.51	4	0.579	10.5	8
	5	1.51	4	0.579	10.5	8
	6	1.5	4	0.577	10.5	8
120	1	2.43	2	0.637	11.6	8
	2	2.43	2	0.637	11.6	8
	3	2.44	2	0.639	11.7	8
	4	2.38	3	0.629	11.5	8
	5	2.37	3	0.629	11.5	8
	6	2.38	3	0.629	11.5	8
121	1	1.54	4	0.648	11.8	8
	2	1.53	4	0.645	11.7	8
	3	1.53	4	0.646	11.7	8
	4	1.53	4	0.645	11.7	8
	5	1.54	4	0.645	11.7	8
	6	1.54	4	0.645	11.7	8
122	1	1.71	4	0.61	11.1	8
	2	1.71	4	0.611	11.1	8
	3	1.71	4	0.611	11.1	8
	4	1.71	4	0.646	11.7	8
	5	1.77	4	0.645	11.7	8
	6	1.77	4	0.646	11.7	8
123	1	2.44	2	0.675	12.3	8
	2	2.44	2	0.675	12.3	8
	3	2.45	2	0.675	12.3	8
	4	2.47	2	0.68	12.4	8
	5	2.46	2	0.68	12.4	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.46	2	0.68	12.4	8
124	1	2.35	3	0.521	9.5	8
	2	2.35	3	0.521	9.5	8
	3	2.34	3	0.521	9.5	8
	4	2.36	3	0.524	9.5	8
	5	2.36	3	0.525	9.5	8
	6	2.35	3	0.525	9.5	8
125	1	2.29	3	0.567	10.3	8
	2	2.3	3	0.566	10.3	8
	3	2.29	3	0.566	10.3	8
	4	2.28	3	0.563	10.2	8
	5	2.27	3	0.562	10.2	8
	6	2.27	3	0.562	10.2	8
126	1	1.66	4	0.521	9.5	8
	2	1.67	4	0.52	9.5	8
	3	1.67	4	0.521	9.5	8
	4	1.71	4	0.535	9.7	8
	5	1.71	4	0.534	9.7	8
	6	1.71	4	0.535	9.7	8
127	1	2.2	3	0.594	10.8	8
	2	2.2	3	0.593	10.8	8
	3	2.2	3	0.593	10.8	8
	4	2.13	3	0.576	10.5	8
	5	2.13	3	0.577	10.5	8
	6	2.14	3	0.577	10.5	8
128	1	1.83	4	0.613	11.1	8
	2	1.83	4	0.613	11.1	8
	3	1.83	4	0.613	11.1	8
	4	1.82	4	0.605	11	8
	5	1.81	4	0.606	11	8
	6	1.82	4	0.605	11	8
129	1	1.54	4	0.553	10.1	8
	2	1.54	4	0.553	10.1	8
	3	1.54	4	0.554	10.1	8
	4	1.59	4	0.573	10.4	8
	5	1.59	4	0.572	10.4	8
	6	1.6	4	0.572	10.4	8
130	1	2.4	2	0.594	10.8	8
	2	2.4	2	0.594	10.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.41	2	0.595	10.8	8
	4	2.41	2	0.598	10.9	8
	5	2.41	2	0.596	10.8	8
	6	2.42	2	0.598	10.9	8
131	1	2.35	3	0.648	11.8	8
	2	2.34	3	0.646	11.7	8
	3	2.36	3	0.647	11.8	8
	4	2.34	3	0.646	11.7	8
	5	2.35	3	0.647	11.8	8
	6	2.34	3	0.647	11.8	8
132	1	2.16	3	0.646	11.7	8
	2	2.16	3	0.645	11.7	8
	3	2.16	3	0.646	11.7	8
	4	2.13	3	0.634	11.5	8
	5	2.14	3	0.633	11.5	8
	6	2.14	3	0.633	11.5	8
133	1	2.52	2	0.646	11.7	8
	2	2.74	1	0.645	11.7	8
	3	2.64	1	0.645	11.7	8
	4	2.81	1	0.674	12.2	8
	5	2.8	1	0.674	12.2	8
	6	2.8	1	0.672	12.2	8
134	1	2.15	3	0.673	12.2	8
	2	2.13	3	0.672	12.2	8
	3	2.16	3	0.673	12.2	8
	4	2.2	3	0.672	12.2	8
	5	2.14	3	0.678	12.3	8
	6	2.14	3	0.677	12.3	8
135	1	1.56	4	0.653	11.9	8
	2	1.56	4	0.652	11.9	8
	3	1.56	4	0.652	11.9	8
	4	1.52	4	0.636	11.6	8
	5	1.52	4	0.634	11.5	8
	6	1.53	4	0.634	11.5	8
136	1	2.49	2	0.596	10.8	8
	2	2.48	2	0.598	10.9	8
	3	2.49	2	0.596	10.8	8
	4	2.47	2	0.591	10.7	8
	5	2.48	2	0.593	10.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.46	2	0.591	10.7	8
137	1	2.3	3	0.605	11	8
	2	2.3	3	0.605	11	8
	3	2.3	3	0.606	11	8
	4	2.26	3	0.6	10.9	8
	5	2.26	3	0.598	10.9	8
	6	2.25	3	0.599	10.9	8
138	1	1.77	4	0.628	11.4	8
	2	1.76	4	0.627	11.4	8
	3	1.77	4	0.628	11.4	8
	4	1.78	4	0.628	11.4	8
	5	1.77	4	0.629	11.4	8
	6	1.77	4	0.629	11.4	8
139	1	2.4	3	0.62	11.3	8
	2	2.4	3	0.62	11.3	8
	3	2.39	3	0.62	11.3	8
	4	2.34	3	0.612	11.1	8
	5	2.35	3	0.612	11.1	8
	6	2.34	3	0.612	11.1	8
140	1	2.24	3	0.601	10.9	8
	2	2.25	3	0.603	11	8
	3	2.26	3	0.604	11	8
	4	2.12	3	0.577	10.5	8
	5	2.12	3	0.577	10.5	8
	6	2.12	3	0.579	10.5	8
141	1	2.33	3	0.618	11.2	8
	2	2.33	3	0.618	11.2	8
	3	2.33	3	0.618	11.2	8
	4	2.26	3	0.609	11.1	8
	5	2.27	3	0.609	11.1	8
	6	2.28	3	0.61	11.1	8
142	1	1.87	4	0.513	9.3	8
	2	1.9	4	0.513	9.3	8
	3	1.85	4	0.513	9.3	8
	4	1.85	4	0.502	9.1	8
	5	1.85	4	0.502	9.1	8
	6	1.85	4	0.501	9.1	8
143	1	2.1	3	0.506	9.2	8
	2	2.11	3	0.508	9.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.11	3	0.508	9.2	8
	4	2.13	3	0.513	9.3	8
	5	2.14	3	0.513	9.3	8
	6	2.14	3	0.513	9.3	8
144	1	1.77	4	0.561	10.2	8
	2	1.78	4	0.561	10.2	8
	3	1.78	4	0.561	10.2	8
	4	1.67	4	0.541	9.8	8
	5	1.69	4	0.542	9.8	8
	6	1.69	4	0.542	9.8	8
145	1	1.17	4	0.614	11.2	8
	2	1.17	4	0.615	11.2	8
	3	1.17	4	0.615	11.2	8
	4	1.04	4	0.546	9.9	8
	5	1.03	4	0.546	9.9	8
	6	1.04	4	0.546	9.9	8
146	1	2.01	4	0.547	9.9	8
	2	2.01	4	0.547	9.9	8
	3	2	4	0.547	9.9	8
	4	1.99	4	0.546	9.9	8
	5	2	4	0.546	9.9	8
	6	1.99	4	0.544	9.9	8
147	1	1.3	4	0.562	10.2	8
	2	1.29	4	0.561	10.2	8
	3	1.3	4	0.561	10.2	8
	4	1.24	4	0.537	9.8	8
	5	1.24	4	0.537	9.8	8
	6	1.23	4	0.535	9.7	8
148	1	0.9	8	0.537	9.8	8
	2	0.9	8	0.535	9.7	8
	3	0.9	8	0.537	9.8	8
	4	0.86	8	0.513	9.3	8
	5	0.86	8	0.511	9.3	8
	6	0.86	8	0.51	9.3	8
149	1	1.3	4	0.562	10.2	8
	2	1.29	4	0.561	10.2	8
	3	1.3	4	0.561	10.2	8
	4	1.24	4	0.537	9.8	8
	5	1.24	4	0.537	9.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.23	4	0.535	9.7	8
150	1	1.33	4	0.468	8.5	8
	2	1.33	4	0.468	8.5	8
	3	1.34	4	0.469	8.5	8
	4	1.31	4	0.458	8.3	8
	5	1.31	4	0.458	8.3	8
	6	1.31	4	0.458	8.3	8
151	1	1.16	4	0.448	8.1	8
	2	1.15	4	0.447	8.1	8
	3	1.16	4	0.448	8.1	8
	4	1.2	4	0.461	8.4	8
	5	1.2	4	0.459	8.3	8
	6	1.2	4	0.461	8.4	8
152	1	1.18	4	0.425	7.7	8
	2	1.19	4	0.425	7.7	8
	3	1.18	4	0.425	7.7	8
	4	1.21	4	0.431	7.8	8
	5	1.21	4	0.431	7.8	8
	6	1.21	4	0.431	7.8	8
153	1	1.12	4	0.547	9.9	8
	2	1.12	4	0.547	9.9	8
	3	1.12	4	0.546	9.9	8
	4	1.11	4	0.546	9.9	8
	5	1.12	4	0.547	9.9	8
	6	1.12	4	0.547	9.9	8
154	1	1.01	4	0.554	10.1	8
	2	1.01	4	0.554	10.1	8
	3	1.01	4	0.554	10.1	8
	4	0.97	8	0.539	9.8	8
	5	0.97	8	0.538	9.8	8
	6	0.97	8	0.538	9.8	8
155	1	1.2	4	0.537	9.7	8
	2	1.19	4	0.534	9.7	8
	3	1.2	4	0.535	9.7	8
	4	1.19	4	0.533	9.7	8
	5	1.19	4	0.533	9.7	8
	6	1.19	4	0.534	9.7	8
156	1	2.12	3	0.505	9	7.9
	2	2.11	3	0.505	9	7.9

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.12	3	0.505	9	7.9
	4	2.17	3	0.587	10.5	7.9
	5	2.11	3	0.506	9.1	7.9
	6	2.12	3	0.505	9	7.9
157	1	1.67	4	0.51	9.1	7.9
	2	1.67	4	0.51	9.1	7.9
	3	1.68	4	0.51	9.1	7.9
	4	1.65	4	0.511	9.2	7.9
	5	1.65	4	0.511	9.2	7.9
	6	1.66	4	0.511	9.2	7.9
158	1	1.95	4	0.514	9.2	7.9
	2	1.95	4	0.514	9.2	7.9
	3	1.95	4	0.514	9.2	7.9
	4	2.04	4	0.541	9.7	7.9
	5	2.04	4	0.541	9.7	7.9
	6	2.05	4	0.541	9.7	7.9
159	1	1.61	4	0.485	8.8	8
	2	1.61	4	0.485	8.8	8
	3	1.61	4	0.485	8.8	8
	4	1.59	4	0.478	8.7	8
	5	1.59	4	0.478	8.7	8
	6	1.59	4	0.478	8.7	8
160	1	1.46	4	0.636	11.6	8
	2	1.46	4	0.636	11.6	8
	3	1.45	4	0.636	11.6	8
	4	1.44	4	0.631	11.5	8
	5	1.44	4	0.632	11.5	8
	6	1.44	4	0.631	11.5	8
161	1	1.91	4	0.511	9.3	8
	2	1.92	4	0.511	9.3	8
	3	1.91	4	0.511	9.3	8
	4	2	4	0.529	9.6	8
	5	2	4	0.528	9.6	8
	6	2	4	0.528	9.6	8
162	1	1.51	4	0.519	9.4	8
	2	1.51	4	0.518	9.4	8
	3	1.51	4	0.518	9.4	8
	4	1.5	4	0.515	9.4	8
	5	1.51	4	0.515	9.4	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.51	4	0.514	9.3	8
163	1	2	4	0.567	10.3	8
	2	1.98	4	0.566	10.3	8
	3	2	4	0.567	10.3	8
	4	1.94	4	0.543	9.9	8
	5	1.94	4	0.543	9.9	8
	6	1.95	4	0.544	9.9	8
164	1	1.41	4	0.48	8.7	8
	2	1.41	4	0.48	8.7	8
	3	1.41	4	0.48	8.7	8
	4	1.44	4	0.485	8.8	8
	5	1.44	4	0.483	8.8	8
	6	1.44	4	0.485	8.8	8
165	1	1.63	4	0.627	11.2	7.9
	2	1.63	4	0.627	11.2	7.9
	3	1.61	4	0.627	11.2	7.9
	4	1.62	4	0.626	11.2	7.9
	5	1.63	4	0.627	11.2	7.9
	6	1.63	4	0.627	11.2	7.9
166	1	1.47	4	0.577	10.5	8
	2	1.44	4	0.577	10.5	8
	3	1.44	4	0.577	10.5	8
	4	1.46	4	0.581	10.6	8
	5	1.46	4	0.581	10.6	8
	6	1.46	4	0.579	10.5	8
167	1	2.02	4	0.587	10.7	8
	2	2.02	4	0.588	10.7	8
	3	2.01	4	0.588	10.7	8
	4	2.07	4	0.597	10.9	8
	5	2.06	4	0.596	10.8	8
	6	2.07	4	0.596	10.8	8
168	1	2.16	3	0.567	10.1	7.9
	2	2.18	3	0.565	10.1	7.9
	3	2.17	3	0.564	10.1	7.9
	4	2.16	3	0.576	10.3	7.9
	5	2.16	3	0.576	10.3	7.9
	6	2.16	3	0.574	10.3	7.9
169	1	1.76	4	0.553	10.1	8
	2	1.77	4	0.555	10.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.77	4	0.554	10.1	8
	4	1.77	4	0.555	10.1	8
	5	1.76	4	0.553	10.1	8
	6	1.77	4	0.555	10.1	8
170	1	2.07	4	0.56	10.2	8
	2	2.07	4	0.559	10.2	8
	3	2.06	4	0.56	10.2	8
	4	2.1	4	0.57	10.4	8
	5	2.12	3	0.57	10.4	8
	6	2.08	4	0.57	10.4	8
171	1	2.04	4	0.524	9.5	8
	2	2.04	4	0.524	9.5	8
	3	2.04	4	0.524	9.5	8
	4	2.04	4	0.524	9.5	8
	5	2.04	4	0.524	9.5	8
	6	2.04	4	0.524	9.5	8
172	1	1.8	4	0.48	8.7	8
	2	1.8	4	0.48	8.7	8
	3	1.8	4	0.48	8.7	8
	4	1.8	4	0.48	8.7	8
	5	1.8	4	0.48	8.7	8
	6	1.8	4	0.48	8.7	8
173	1	2.05	4	0.528	9.6	8
	2	2.05	4	0.528	9.6	8
	3	2.05	4	0.528	9.6	8
	4	2.06	4	0.528	9.6	8
	5	2.06	4	0.528	9.6	8
	6	2.06	4	0.528	9.6	8
174	1	1.92	4	0.578	10.5	8
	2	1.92	4	0.577	10.5	8
	3	1.92	4	0.577	10.5	8
	4	1.86	4	0.559	10.2	8
	5	1.86	4	0.559	10.2	8
	6	1.85	4	0.56	10.2	8
175	1	1.43	4	0.54	9.8	8
	2	1.42	4	0.539	9.8	8
	3	1.44	4	0.54	9.8	8
	5	1.35	4	0.511	9.3	8
	6	1.35	4	0.51	9.3	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	7	1.35	4	0.51	9.3	8
176	1	1.66	4	0.553	10.1	8
	2	1.66	4	0.554	10.1	8
	3	1.66	4	0.553	10.1	8
	4	1.64	4	0.546	9.9	8
	5	1.64	4	0.546	9.9	8
	6	1.65	4	0.545	9.9	8
177	1	2.57	2	0.627	11.4	8
	2	2.57	2	0.627	11.4	8
	3	2.57	2	0.627	11.4	8
	4	2.55	2	0.625	11.4	8
	5	2.56	2	0.627	11.4	8
	6	2.56	2	0.627	11.4	8
178	1	2.36	3	0.635	11.6	8
	2	2.36	3	0.634	11.5	8
	3	2.34	3	0.632	11.5	8
	4	2.53	2	0.678	12.3	8
	5	2.54	2	0.679	12.4	8
	6	2.53	2	0.678	12.3	8
179	1	2.29	3	0.636	11.6	8
	2	2.31	3	0.637	11.6	8
	3	2.31	3	0.637	11.6	8
	4	2.3	3	0.636	11.6	8
	5	2.3	3	0.639	11.6	8
	6	2.31	3	0.637	11.6	8
180	1	2.35	3	0.697	12.7	8
	2	2.35	3	0.696	12.7	8
	3	2.35	3	0.694	12.6	8
	4	2.36	3	0.698	12.7	8
	5	2.36	3	0.697	12.7	8
	6	2.36	3	0.696	12.7	8
181	1	1.9	4	0.749	13.6	8
	2	1.9	4	0.749	13.6	8
	3	1.89	4	0.749	13.6	8
	4	1.9	4	0.75	13.6	8
	5	1.9	4	0.749	13.6	8
	6	1.9	4	0.749	13.6	8
182	1	1.68	4	0.667	12.1	8
	2	1.7	4	0.669	12.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.7	4	0.669	12.2	8
	4	1.7	4	0.669	12.2	8
	5	1.69	4	0.667	12.1	8
	6	1.7	4	0.668	12.2	8
183	1	2.57	2	0.673	12.1	7.9
	2	2.57	2	0.674	12.1	7.9
	3	2.57	2	0.674	12.1	7.9
	4	2.52	2	0.66	11.9	7.9
	5	2.52	2	0.662	11.9	7.9
	6	2.52	2	0.66	11.9	7.9
184	1	1.91	4	0.617	11.1	7.9
	2	1.89	4	0.616	11.1	7.9
	3	1.91	4	0.617	11.1	7.9
	4	1.99	4	0.645	11.6	7.9
	5	1.99	4	0.645	11.6	7.9
	6	1.98	4	0.644	11.6	7.9
185	1	1.91	4	0.617	11.1	7.9
	2	1.89	4	0.616	11.1	7.9
	3	1.91	4	0.617	11.1	7.9
	4	1.99	4	0.645	11.6	7.9
	5	1.99	4	0.645	11.6	7.9
	6	1.98	4	0.644	11.6	7.9
186	1	2.45	2	0.591	10.7	8
	2	2.45	2	0.589	10.7	8
	3	2.38	3	0.574	10.4	8
	4	2.38	3	0.575	10.5	8
	5	2.38	3	0.574	10.4	8
	6	2.38	3	0.574	10.4	8
187	1	2.18	3	0.577	10.5	8
	2	2.19	3	0.575	10.5	8
	3	2.19	3	0.575	10.5	8
	4	2.2	3	0.586	10.7	8
	5	2.21	3	0.588	10.7	8
	6	2.21	3	0.587	10.7	8
188	1	2.76	1	0.616	11.2	8
	2	2.78	1	0.617	11.2	8
	3	2.78	1	0.617	11.2	8
	4	2.74	1	0.613	11.2	8
	5	2.73	1	0.612	11.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.74	1	0.612	11.1	8
189	1	3.7	1	0.763	13.9	8
	2	3.7	1	0.763	13.9	8
	3	3.72	1	0.761	13.9	8
	4	3.44	1	0.732	13.3	8
	5	3.46	1	0.732	13.3	8
	6	3.45	1	0.731	13.3	8
190	1	3.42	1	0.729	13.3	8
	2	3.44	1	0.729	13.3	8
	3	3.42	1	0.727	13.2	8
	4	3.5	1	0.751	13.7	8
	5	3.52	1	0.75	13.6	8
	6	3.52	1	0.75	13.6	8
191	1	3.5	1	0.711	12.9	8
	2	3.49	1	0.711	12.9	8
	3	3.52	1	0.713	13	8
	4	3.03	1	0.718	13.1	8
	5	3.54	1	0.732	13.3	8
	6	3.54	1	0.732	13.3	8
192	1	3.63	1	0.75	13.6	8
	2	3.64	1	0.75	13.6	8
	3	3.6	1	0.749	13.6	8
	4	3.69	1	0.759	13.8	8
	5	3.67	1	0.759	13.8	8
	6	3.7	1	0.759	13.8	8
193	1	3.75	1	0.778	14.2	8
	2	3.74	1	0.779	14.2	8
	3	3.76	1	0.778	14.2	8
	4	3.67	1	0.779	14.2	8
	5	3.68	1	0.78	14.2	8
	6	3.69	1	0.78	14.2	8
194	1	3.58	1	0.758	13.8	8
	2	3.58	1	0.758	13.8	8
	3	3.58	1	0.758	13.8	8
	4	3.57	1	0.759	13.8	8
	5	3.55	1	0.759	13.8	8
	6	3.58	1	0.758	13.8	8
195	1	2.08	4	0.54	9.8	8
	2	2.08	4	0.54	9.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.08	4	0.54	9.8	8
	4	2.09	4	0.54	9.8	8
	5	1.99	4	0.54	9.8	8
	6	2.01	4	0.54	9.8	8
196	1	2.14	3	0.551	10	8
	2	2.14	3	0.551	10	8
	3	2.14	3	0.551	10	8
	4	2.09	3	0.551	10	8
	5	2.09	3	0.551	10	8
	6	2.09	3	0.551	10	8
197	1	2.5	2	0.583	10.6	8
	2	2.5	2	0.583	10.6	8
	3	2.5	2	0.583	10.6	8
	4	2.38	2	0.583	10.6	8
	5	2.38	2	0.583	10.6	8
	6	2.38	2	0.583	10.6	8
198	1	2.79	1	0.631	11.5	8
	2	2.81	1	0.634	11.5	8
	3	2.8	1	0.634	11.5	8
	4	2.86	1	0.649	11.8	8
	5	2.89	1	0.65	11.8	8
	6	2.89	1	0.65	11.8	8
199	1	2.49	2	0.597	10.9	8
	2	2.48	2	0.598	10.9	8
	3	2.49	2	0.597	10.9	8
	4	2.6	2	0.625	11.4	8
	5	2.61	1	0.625	11.4	8
	6	2.61	1	0.624	11.3	8
200	1	2.34	3	0.575	10.5	8
	2	2.33	3	0.575	10.5	8
	3	2.35	3	0.577	10.5	8
	4	2.42	2	0.6	10.9	8
	5	2.43	2	0.596	10.8	8
	6	2.44	2	0.596	10.8	8
201	1	2.13	3	0.693	12.6	8
	2	2.13	3	0.693	12.6	8
	3	2.13	3	0.693	12.6	8
	4	2	4	0.655	11.9	8
	5	2	4	0.657	11.9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.99	4	0.655	11.9	8
202	1	2.32	3	0.738	13.4	8
	2	2.33	3	0.736	13.4	8
	3	2.33	3	0.736	13.4	8
	4	2.2	3	0.684	12.4	8
	5	2.2	3	0.683	12.4	8
	6	2.2	3	0.683	12.4	8
203	1	2.2	3	0.602	11	8
	2	2.22	3	0.603	11	8
	3	2.2	3	0.603	11	8
	4	2.19	3	0.601	10.9	8
	5	2.18	3	0.601	10.9	8
	6	2.19	3	0.601	10.9	8
204	1	2.25	3	0.616	11.2	8
	2	2.25	3	0.615	11.2	8
	3	2.24	3	0.615	11.2	8
	4	2.25	3	0.624	11.3	8
	5	2.23	3	0.622	11.3	8
	6	2.25	3	0.624	11.3	8
205	1	2.49	2	0.615	11.2	8
	2	2.5	2	0.615	11.2	8
	3	2.49	2	0.615	11.2	8
	4	2.53	2	0.627	11.4	8
	5	2.54	2	0.627	11.4	8
	6	2.54	2	0.627	11.4	8
206	1	1.89	4	0.597	10.8	8
	2	1.87	4	0.596	10.8	8
	3	1.89	4	0.597	10.8	8
	4	1.97	4	0.626	11.4	8
	5	1.96	4	0.626	11.4	8
	6	1.98	4	0.626	11.4	8
207	1	2.05	4	0.706	12.8	8
	2	2.05	4	0.705	12.8	8
	3	2.05	4	0.703	12.8	8
	4	1.98	4	0.675	12.3	8
	5	1.98	4	0.675	12.3	8
	6	1.99	4	0.675	12.3	8
208	1	1.87	4	0.713	13	8
	2	1.87	4	0.712	13	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.87	4	0.713	13	8
	4	1.76	4	0.67	12.2	8
	5	1.76	4	0.672	12.2	8
	6	1.75	4	0.67	12.2	8
209	1	2.42	2	0.687	12.5	8
	2	2.42	2	0.688	12.5	8
	3	2.41	2	0.687	12.5	8
	4	2.4	3	0.682	12.4	8
	5	2.4	3	0.682	12.4	8
	6	2.4	3	0.682	12.4	8
210	1	3.04	1	0.707	12.9	8
	2	3.04	1	0.707	12.9	8
	3	3.05	1	0.706	12.8	8
	4	2.95	1	0.684	12.4	8
	5	2.95	1	0.686	12.5	8
	6	2.95	1	0.684	12.4	8
211	1	2.58	2	0.72	13.1	8
	2	2.58	2	0.72	13.1	8
	3	2.59	2	0.718	13.1	8
	4	2.42	2	0.675	12.3	8
	5	2.41	2	0.675	12.3	8
	6	2.42	2	0.674	12.3	8
212	1	2.5	2	0.694	12.6	8
	2	2.49	2	0.693	12.6	8
	3	2.5	2	0.693	12.6	8
	4	2.48	2	0.688	12.5	8
	5	2.48	2	0.688	12.5	8
	6	2.48	2	0.688	12.5	8
213	1	2.06	4	0.588	10.7	8
	2	2.08	4	0.588	10.7	8
	3	2.08	4	0.589	10.7	8
	4	2.13	3	0.602	10.9	8
	5	2.12	3	0.601	10.9	8
	6	2.12	3	0.601	10.9	8
214	1	2.14	3	0.588	10.7	8
	2	2.13	3	0.588	10.7	8
	3	2.14	3	0.588	10.7	8
	4	2.2	3	0.603	11	8
	5	2.19	3	0.603	11	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.2	3	0.603	11	8
215	1	2.26	3	0.541	9.8	8
	2	2.27	3	0.54	9.8	8
	3	2.26	3	0.54	9.8	8
	4	2.34	3	0.554	10.1	8
	5	2.34	3	0.555	10.1	8
	6	2.35	3	0.555	10.1	8
216	1	2.22	3	0.534	9.7	8
	2	2.23	3	0.532	9.7	8
	3	2.23	3	0.532	9.7	8
	4	2.33	3	0.558	10.1	8
	5	2.33	3	0.558	10.1	8
	6	2.32	3	0.559	10.2	8
217	1	2.44	2	0.548	10	8
	2	2.43	2	0.548	10	8
	3	2.41	2	0.546	9.9	8
	4	2.49	2	0.562	10.2	8
	5	2.48	2	0.562	10.2	8
	6	2.48	2	0.56	10.2	8
218	1	2.01	4	0.508	9.2	8
	2	2.01	4	0.508	9.2	8
	3	2.01	4	0.508	9.2	8
	4	2.03	4	0.511	9.3	8
	5	2.03	4	0.511	9.3	8
	6	2.01	4	0.51	9.3	8
219	1	2.12	3	0.53	9.6	8
	2	2.11	3	0.527	9.6	8
	3	2.14	3	0.529	9.6	8
	4	2.18	3	0.544	9.9	8
	5	2.19	3	0.543	9.9	8
	6	2.19	3	0.544	9.9	8
220	1	2.26	3	0.526	9.6	8
	2	2.27	3	0.525	9.6	8
	3	2.27	3	0.525	9.6	8
	4	2.29	3	0.527	9.6	8
	5	2.27	3	0.527	9.6	8
	6	2.3	3	0.529	9.6	8
221	1	2.4	2	0.56	10.2	8
	2	2.4	2	0.56	10.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.38	3	0.559	10.2	8
	4	2.38	3	0.559	10.2	8
	5	2.39	3	0.56	10.2	8
	6	2.4	3	0.56	10.2	8
222	1	2.31	3	0.581	10.5	8
	2	2.32	3	0.579	10.5	8
	3	2.31	3	0.581	10.5	8
	4	2.24	3	0.568	10.3	8
	5	2.23	3	0.567	10.3	8
	6	2.25	3	0.567	10.3	8
223	1	2.04	4	0.559	10.1	8
	2	2.03	4	0.558	10.1	8
	3	2.03	4	0.559	10.1	8
	4	2.03	4	0.559	10.1	8
	5	2.02	4	0.559	10.1	8
	6	2.03	4	0.559	10.1	8
224	1	2.14	3	0.563	10.2	8
	2	2.15	3	0.564	10.2	8
	3	2.15	3	0.564	10.2	8
	4	2.04	4	0.541	9.8	8
	5	2.05	4	0.541	9.8	8
	6	2.03	4	0.541	9.8	8
225	1	2.19	3	0.616	11.2	8
	2	2.19	3	0.617	11.2	8
	3	2.19	3	0.617	11.2	8
	4	2.17	3	0.61	11.1	8
	5	2.17	3	0.608	11.1	8
	6	2.17	3	0.608	11.1	8
226	1	1.92	4	0.62	11.3	8
	2	1.92	4	0.62	11.3	8
	3	1.92	4	0.62	11.3	8
	4	1.87	4	0.607	11	8
	5	1.87	4	0.607	11	8
	6	1.87	4	0.607	11	8
227	1	2.45	2	0.621	11.3	8
	2	2.46	2	0.622	11.3	8
	3	2.46	2	0.622	11.3	8
	4	2.42	2	0.617	11.2	8
	5	2.41	2	0.615	11.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.43	2	0.615	11.2	8
228	1	1.63	4	0.5	9.1	8
	2	1.63	4	0.5	9.1	8
	3	1.63	4	0.5	9.1	8
	4	1.58	4	0.483	8.8	8
	5	1.58	4	0.484	8.8	8
	6	1.58	4	0.484	8.8	8
229	1	2	4	0.53	9.6	8
	2	2.01	4	0.53	9.6	8
	3	2.01	4	0.53	9.6	8
	4	1.87	4	0.506	9.2	8
	5	1.89	4	0.506	9.2	8
	6	1.89	4	0.506	9.2	8
230	1	2.15	3	0.515	9.4	8
	2	2.17	3	0.516	9.4	8
	3	2.17	3	0.516	9.4	8
	4	2.1	3	0.502	9.1	8
	5	2.11	3	0.502	9.1	8
	6	2.11	3	0.502	9.1	8
231	1	2.29	3	0.546	9.9	8
	2	2.29	3	0.546	9.9	8
	3	2.28	3	0.546	9.9	8
	4	2.23	3	0.539	9.8	8
	5	2.23	3	0.538	9.8	8
	6	2.24	3	0.538	9.8	8
232	1	1.81	4	0.549	10	8
	2	1.82	4	0.548	10	8
	3	1.81	4	0.548	10	8
	4	1.76	4	0.534	9.7	8
	5	1.77	4	0.535	9.7	8
	6	1.76	4	0.535	9.7	8
233	1	1.95	4	0.524	9.5	8
	2	1.96	4	0.522	9.5	8
	3	1.96	4	0.524	9.5	8
	4	1.88	4	0.503	9.2	8
	5	1.89	4	0.505	9.2	8
	6	1.89	4	0.505	9.2	8
234	1	1.73	4	0.636	11.6	8
	2	1.72	4	0.635	11.5	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.73	4	0.636	11.6	8
	4	1.72	4	0.636	11.6	8
	5	1.72	4	0.636	11.6	8
	6	1.72	4	0.635	11.5	8
235	1	2.11	3	0.663	12	8
	2	2.11	3	0.663	12	8
	3	2.12	3	0.663	12	8
	4	2.03	4	0.635	11.5	8
	5	2.03	4	0.635	11.5	8
	6	2.03	4	0.635	11.5	8
236	1	2.66	1	0.655	11.9	8
	2	2.66	1	0.655	11.9	8
	3	2.66	1	0.655	11.9	8
	4	2.68	1	0.651	11.8	8
	5	2.68	1	0.651	11.8	8
	6	2.67	1	0.653	11.9	8
237	1	2.45	2	0.612	11.1	8
	2	2.44	2	0.612	11.1	8
	3	2.44	2	0.613	11.2	8
	4	2.42	2	0.603	11	8
	5	2.41	2	0.602	11	8
	6	2.41	2	0.602	11	8
238	1	2.44	2	0.619	11.3	8
	2	2.46	2	0.62	11.3	8
	3	2.45	2	0.62	11.3	8
	4	2.55	2	0.64	11.6	8
	5	2.55	2	0.64	11.6	8
	6	2.55	2	0.64	11.6	8
239	1	2.53	2	0.606	11	8
	2	2.53	2	0.607	11	8
	3	2.52	2	0.606	11	8
	4	2.64	1	0.635	11.6	8
	5	2.67	1	0.637	11.6	8
	6	2.66	1	0.636	11.6	8
240	1	2.16	3	0.62	11.3	8
	2	2.17	3	0.619	11.3	8
	3	2.18	3	0.619	11.3	8
	4	2.13	3	0.608	11.1	8
	5	2.14	3	0.61	11.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.14	3	0.61	11.1	8
241	1	1.3	4	0.659	12	8
	2	1.31	4	0.66	12	8
	3	1.3	4	0.662	12	8
	4	1.31	4	0.667	12.1	8
	5	1.31	4	0.668	12.2	8
	6	1.31	4	0.668	12.2	8
242	1	1.5	4	0.587	10.7	8
	2	1.49	4	0.587	10.7	8
	3	1.5	4	0.588	10.7	8
	4	1.51	4	0.592	10.8	8
	5	1.51	4	0.591	10.7	8
	6	1.51	4	0.589	10.7	8
243	1	2.13	3	0.564	10.2	8
	2	2.15	3	0.564	10.2	8
	3	2.11	3	0.564	10.2	8
	4	2.22	3	0.582	10.6	8
	5	2.23	3	0.582	10.6	8
	6	2.23	3	0.582	10.6	8
244	1	1.5	4	0.575	10.4	8
	2	1.49	4	0.574	10.4	8
	3	1.48	4	0.574	10.4	8
	4	1.55	4	0.593	10.8	8
	5	1.55	4	0.592	10.7	8
	6	1.55	4	0.592	10.7	8
245	1	2.16	3	0.565	10.3	8
	2	2.16	3	0.565	10.3	8
	3	2.15	3	0.565	10.3	8
	4	2.22	3	0.581	10.5	8
	5	2.23	3	0.581	10.5	8
	6	2.23	3	0.581	10.5	8
246	1	1.89	4	0.478	8.7	8
	2	1.89	4	0.478	8.7	8
	3	1.89	4	0.478	8.7	8
	4	1.96	4	0.496	9	8
	5	1.96	4	0.496	9	8
	6	1.95	4	0.496	9	8
247	1	1.61	4	0.488	8.9	8
	2	1.6	4	0.487	8.9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.6	4	0.487	8.9	8
	4	1.58	4	0.484	8.8	8
	5	1.59	4	0.483	8.8	8
	6	1.59	4	0.484	8.8	8
248	1	1.79	4	0.478	8.7	8
	2	1.77	4	0.478	8.7	8
	3	1.79	4	0.478	8.7	8
	4	1.75	4	0.472	8.6	8
	5	1.76	4	0.474	8.6	8
	6	1.76	4	0.473	8.6	8
249	1	2.12	3	0.506	9.2	8
	2	2.15	3	0.507	9.2	8
	3	2.15	3	0.508	9.3	8
	4	2.1	3	0.502	9.1	8
	5	2.11	3	0.502	9.1	8
	6	2.1	3	0.501	9.1	8
250	1	1.85	4	0.496	9	8
	2	1.86	4	0.496	9	8
	3	1.86	4	0.496	9	8
	4	1.89	4	0.511	9.3	8
	5	1.9	4	0.51	9.3	8
	6	1.89	4	0.51	9.3	8
251	1	1.89	4	0.506	9.2	8
	2	1.89	4	0.506	9.2	8
	3	1.9	4	0.506	9.2	8
	4	1.83	4	0.497	9	8
	5	1.82	4	0.495	9	8
	6	1.83	4	0.496	9	8
252	1	1.8	4	0.519	9.4	8
	2	1.79	4	0.519	9.4	8
	3	1.8	4	0.52	9.5	8
	4	1.73	4	0.502	9.1	8
	5	1.73	4	0.5	9.1	8
	6	1.72	4	0.5	9.1	8
253	1	1.75	4	0.546	9.9	8
	2	1.73	4	0.543	9.9	8
	3	1.75	4	0.545	9.9	8
	4	1.74	4	0.544	9.9	8
	5	1.74	4	0.543	9.9	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.74	4	0.544	9.9	8
254	1	2.3	3	0.565	10.3	8
	2	2.31	3	0.563	10.2	8
	3	2.31	3	0.564	10.3	8
	4	2.24	3	0.548	10	8
	5	2.26	3	0.55	10	8
	6	2.25	3	0.55	10	8
255	1	2.25	3	0.62	11.3	8
	2	2.25	3	0.622	11.3	8
	3	2.26	3	0.622	11.3	8
	4	2.28	3	0.626	11.4	8
	5	2.29	3	0.627	11.4	8
	6	2.29	3	0.626	11.4	8
256	1	2.32	3	0.673	12.2	8
	2	2.32	3	0.672	12.2	8
	3	2.33	3	0.672	12.2	8
	4	2.32	3	0.67	12.2	8
	5	2.32	3	0.672	12.2	8
	6	2.31	3	0.672	12.2	8
257	1	2.68	1	0.655	11.9	8
	2	2.67	1	0.654	11.9	8
	3	2.68	1	0.654	11.9	8
	4	2.67	1	0.656	11.9	8
	5	2.67	1	0.655	11.9	8
	6	2.68	1	0.654	11.9	8
258	1	3.18	1	0.698	12.7	8
	2	3.18	1	0.698	12.7	8
	3	3.18	1	0.698	12.7	8
	4	3.17	1	0.698	12.7	8
	5	3.15	1	0.697	12.7	8
	6	3.15	1	0.697	12.7	8
259	1	2.15	3	0.653	11.9	8
	2	2.15	3	0.651	11.9	8
	3	2.15	3	0.653	11.9	8
	4	2.14	3	0.653	11.9	8
	5	2.16	3	0.653	11.9	8
	6	2.16	3	0.651	11.9	8
260	1	2.13	3	0.668	12.2	8
	2	2.12	3	0.668	12.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.13	3	0.669	12.2	8
	4	2.09	4	0.659	12	8
	5	2.08	4	0.656	11.9	8
	6	2.08	4	0.658	12	8
261	1	2.84	1	0.672	12.2	8
	2	2.82	1	0.67	12.2	8
	3	2.83	1	0.67	12.2	8
	4	2.83	1	0.67	12.2	8
	5	2.83	1	0.672	12.2	8
	6	2.84	1	0.672	12.2	8
262	1	3.05	1	0.711	12.9	8
	2	3.04	1	0.713	13	8
	3	3.05	1	0.712	13	8
	4	2.98	1	0.691	12.6	8
	5	2.96	1	0.688	12.5	8
	6	2.98	1	0.691	12.6	8
263	1	3.1	1	0.688	12.5	8
	2	3.08	1	0.686	12.5	8
	3	3.12	1	0.687	12.5	8
	4	3.16	1	0.702	12.8	8
	5	3.17	1	0.705	12.8	8
	6	3.16	1	0.702	12.8	8
264	1	2.59	2	0.581	10.6	8
	2	2.6	2	0.582	10.6	8
	3	2.59	2	0.581	10.6	8
	4	2.6	1	0.583	10.6	8
	5	2.58	2	0.582	10.6	8
	6	2.59	2	0.583	10.6	8
265	1	2.35	3	0.608	11.1	8
	2	2.35	3	0.606	11	8
	3	2.37	3	0.607	11	8
	4	2.28	3	0.593	10.8	8
	5	2.3	3	0.596	10.8	8
	6	2.3	3	0.596	10.8	8
266	1	2.41	2	0.591	10.7	8
	2	2.4	3	0.591	10.7	8
	3	2.41	2	0.591	10.7	8
	4	2.42	2	0.592	10.8	8
	5	2.42	2	0.592	10.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.42	2	0.592	10.8	8
267	1	2.49	2	0.55	10	8
	2	2.49	2	0.55	10	8
	3	2.48	2	0.55	10	8
	4	2.48	2	0.549	10	8
	5	2.49	2	0.55	10	8
	6	2.47	2	0.55	10	8
268	1	2.44	2	0.568	10.3	8
	2	2.46	2	0.569	10.3	8
	3	2.45	2	0.569	10.3	8
	4	2.52	2	0.582	10.6	8
	5	2.53	2	0.581	10.5	8
	6	2.51	2	0.581	10.5	8
269	1	2.31	3	0.574	10.4	8
	2	2.31	3	0.573	10.4	8
	3	2.31	3	0.573	10.4	8
	4	2.3	3	0.577	10.5	8
	5	2.32	3	0.578	10.5	8
	6	2.33	3	0.578	10.5	8
270	1	1.75	4	0.57	10.4	8
	2	1.75	4	0.568	10.3	8
	3	1.74	4	0.568	10.3	8
	4	1.75	4	0.57	10.4	8
	5	1.74	4	0.567	10.3	8
	6	1.75	4	0.568	10.3	8
271	1	1.8	4	0.538	9.8	8
	2	1.79	4	0.536	9.8	8
	3	1.8	4	0.538	9.8	8
	4	1.81	4	0.543	9.9	8
	5	1.82	4	0.543	9.9	8
	6	1.81	4	0.541	9.8	8
272	1	1.43	4	0.51	9.3	8
	2	1.44	4	0.511	9.3	8
	3	1.44	4	0.511	9.3	8
	4	1.36	4	0.517	9.4	8
	5	1.43	4	0.51	9.3	8
	6	1.44	4	0.51	9.3	8
273	1	1.19	4	0.506	9.2	8
	2	1.19	4	0.506	9.2	8

Table 6.5 (Cont'd)

Sample group number	**Sub Samples**	**MOE**	**G RADE**	**SG**	**Weight [lbs]**	**Length [ft]**
	3	1.19	4	0.505	9.2	8
	4	1.2	4	0.51	9.3	8
	5	1.2	4	0.51	9.3	8
	6	1.2	4	0.508	9.3	8
274	1	1.33	4	0.525	9.6	8
	2	1.33	4	0.525	9.6	8
	3	1.34	4	0.526	9.6	8
	4	1.34	4	0.529	9.6	8
	5	1.34	4	0.529	9.6	8
	6	1.34	4	0.529	9.6	8
275	1	2.56	2	0.681	12.4	8
	2	2.54	2	0.681	12.4	8
	3	2.55	2	0.681	12.4	8
	4	2.47	2	0.662	12	8
	5	2.46	2	0.662	12	8
	6	2.46	2	0.662	12	8
276	1	2.09	4	0.622	11.3	8
	2	2.1	4	0.621	11.3	8
	3	2.09	4	0.621	11.3	8
	4	1.97	4	0.586	10.7	8
	5	1.95	4	0.583	10.6	8
	6	1.96	4	0.584	10.6	8
277	1	2	4	0.589	10.7	8
	2	1.99	4	0.589	10.7	8
	3	2	4	0.589	10.7	8
	4	1.98	4	0.581	10.6	8
	5	1.97	4	0.581	10.6	8
	6	1.98	4	0.581	10.6	8
278	1	1.54	4	0.515	9.4	8
	2	1.54	4	0.514	9.3	8
	3	1.54	4	0.514	9.3	8
	4	1.52	4	0.506	9.2	8
	5	1.52	4	0.503	9.2	8
	6	1.52	4	0.505	9.2	8
279	1	1.53	4	0.479	8.7	8
	2	1.52	4	0.478	8.7	8
	3	1.53	4	0.478	8.7	8
	4	1.56	4	0.481	8.7	8
	5	1.56	4	0.482	8.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.56	4	0.482	8.8	8
280	1	1.88	4	0.52	9.5	8
	2	1.88	4	0.52	9.5	8
	3	1.88	4	0.521	9.5	8
	4	2.02	4	0.524	9.5	8
	5	2.01	4	0.524	9.5	8
	6	2.01	4	0.524	9.5	8
281	1	1.87	4	0.544	9.9	8
	2	1.87	4	0.543	9.9	8
	3	1.87	4	0.544	9.9	8
	4	1.78	4	0.52	9.5	8
	5	1.79	4	0.52	9.5	8
	6	1.8	4	0.521	9.5	8
282	1	1.79	4	0.52	9.5	8
	2	1.79	4	0.519	9.4	8
	3	1.79	4	0.519	9.4	8
	4	1.72	4	0.505	9.2	8
	5	1.72	4	0.505	9.2	8
	6	1.73	4	0.505	9.2	8
283	1	1.74	4	0.543	9.9	8
	2	1.74	4	0.543	9.9	8
	3	1.74	4	0.543	9.9	8
	4	1.69	4	0.532	9.7	8
	5	1.69	4	0.532	9.7	8
	6	1.69	4	0.532	9.7	8
284	1	1.54	4	0.593	10.8	8
	2	1.54	4	0.593	10.8	8
	3	1.54	4	0.592	10.8	8
	4	1.57	4	0.606	11	8
	5	1.57	4	0.606	11	8
	6	1.57	4	0.606	11	8
285	1	1.17	4	0.62	11.3	8
	2	1.17	4	0.621	11.3	8
	3	1.17	4	0.621	11.3	8
	4	1.16	4	0.619	11.3	8
	5	1.17	4	0.62	11.3	8
	6	1.16	4	0.62	11.3	8
286	1	1.5	4	0.65	11.8	8
	2	1.5	4	0.65	11.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	1.5	4	0.65	11.8	8
	4	1.45	4	0.63	11.4	8
	5	1.45	4	0.629	11.4	8
	6	1.46	4	0.63	11.4	8
287	1	2.59	2	0.66	12	8
	2	2.6	2	0.66	12	8
	3	2.6	2	0.66	12	8
	4	2.5	2	0.688	12.5	8
	5	2.5	2	0.687	12.5	8
	6	2.5	2	0.687	12.5	8
288	1	2.35	3	0.688	12.5	8
	2	2.37	3	0.691	12.6	8
	3	2.37	3	0.689	12.5	8
	4	2.45	2	0.717	13	8
	5	2.45	2	0.715	13	8
	6	2.45	2	0.715	13	8
289	1	2.7	1	0.682	12.4	8
	2	2.71	1	0.682	12.4	8
	3	2.7	1	0.682	12.4	8
	4	2.85	1	0.717	13	8
	5	2.84	1	0.717	13	8
	6	2.88	1	0.717	13	8
290	1	2	4	0.612	11.1	8
	2	2.01	4	0.613	11.1	8
	3	2.02	4	0.614	11.2	8
	4	1.98	4	0.603	11	8
	5	1.98	4	0.605	11	8
	6	1.99	4	0.604	11	8
291	1	1.98	4	0.605	11	8
	2	1.99	4	0.606	11	8
	3	1.99	4	0.605	11	8
	4	2.01	4	0.625	11.4	8
	5	2.04	4	0.621	11.3	8
	6	2.04	4	0.621	11.3	8
292	1	1.98	4	0.569	10.4	8
	2	1.99	4	0.57	10.4	8
	3	1.98	4	0.57	10.4	8
	4	2.09	4	0.594	10.8	8
	5	2.08	4	0.594	10.8	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.1	4	0.594	10.8	8
293	1	2.51	2	0.616	11.2	8
	2	2.51	2	0.615	11.2	8
	3	2.51	2	0.616	11.2	8
	4	2.47	2	0.612	11.1	8
	5	2.46	2	0.611	11.1	8
	6	2.48	2	0.612	11.1	8
294	1	2.19	3	0.662	12	8
	2	2.19	3	0.662	12	8
	3	2.19	3	0.664	12	8
	4	2.19	3	0.664	12	8
	5	2.18	3	0.662	12	8
	6	2.18	3	0.662	12	8
295	1	2.58	2	0.703	12.7	8
	2	2.59	2	0.704	12.7	8
	3	2.58	2	0.704	12.7	8
	4	2.58	2	0.703	12.7	8
	5	2.57	2	0.706	12.8	8
	6	2.59	2	0.706	12.8	8
296	1	1.33	4	0.559	10.2	8
	2	1.33	4	0.56	10.2	8
	3	1.33	4	0.559	10.2	8
	4	1.33	4	0.559	10.2	8
	5	1.33	4	0.559	10.2	8
	6	1.32	4			
297	1	1.5	4	0.554	10.1	8
	2	1.47	4	0.554	10.1	8
	3	1.45	4	0.527	9.6	8
	4	1.4	4	0.527	9.6	8
	5	1.4	4	0.526	9.6	8
	6	1.4	4			
298	1	1.77	4	0.541	9.8	8
	2	1.77	4	0.54	9.8	8
	3	1.76	4	0.557	10.1	8
	4	1.8	4	0.559	10.2	8
	5	1.81	4	0.557	10.1	8
	6	1.8	4			
299	1	2.04	4	0.67	12.2	8
	2	2.04	4	0.669	12.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.04	4	0.64	11.6	8
	4	1.96	4	0.64	11.6	8
	5	1.96	4	0.64	11.6	8
	6	1.95	4			
300	1	1.37	4	0.617	11.2	8
	2	1.36	4	0.617	11.2	8
	3	1.36	4	0.616	11.2	8
	4	1.36	4	0.616	11.2	8
	5	1.36	4	0.616	11.2	8
	6	1.36	4			
301	1	1.76	4	0.672	12.2	8
	2	1.76	4	0.672	12.2	8
	3	1.75	4	0.677	12.3	8
	4	1.77	4	0.678	12.3	8
	5	1.77	4	0.677	12.3	8
	6	1.76	4			
302	1	2.38	3	0.637	11.4	7.9
	2	2.37	3	0.637	11.4	7.9
	3	2.38	3	0.636	11.4	7.9
	4	2.36	3	0.636	11.4	7.9
	5	2.35	3	0.636	11.4	7.9
	6	2.35	3			
303	1	2.11	3	0.581	10.6	8
	2	2.11	3	0.581	10.6	8
	3	2.1	3	0.582	10.6	8
	4	2.11	3	0.581	10.6	8
	5	2.11	3	0.581	10.6	8
	6	2.11	3			
304	1	1.99	4	0.584	10.6	8
	2	1.99	4	0.586	10.7	8
	3	2	4	0.583	10.6	8
	4	1.99	4	0.583	10.6	8
	5	2	4	0.583	10.6	8
	6	2	4			
305	1	1.73	4	0.594	10.8	8
	2	1.72	4	0.594	10.8	8
	3	1.73	4	0.582	10.6	8
	4	1.66	4	0.579	10.5	8
	5	1.65	4	0.581	10.6	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.66	4			
306	1	1.58	4	0.64	11.6	8
	2	1.59	4	0.64	11.6	8
	3	1.59	4	0.593	10.8	8
	4	1.46	4	0.591	10.7	8
	5	1.43	4	0.593	10.8	8
	6	1.43	4			
307	1	1.46	4	0.584	10.6	8
	2	1.46	4	0.586	10.7	8
	3	1.47	4	0.589	10.7	8
	5	1.44	4	0.588	10.7	8
	6	1.44	4			
	1	2.1	3	0.578	10.5	8
308	2	2.11	3	0.578	10.5	8
	3	2.11	3	0.593	10.8	8
	4	2.08	4	0.592	10.8	8
	5	2.15	3	0.592	10.8	8
	6	2.15	3			
	1	2.3	3	0.578	10.5	8
309	2	2.3	3	0.579	10.5	8
	3	2.3	3	0.606	11	8
	4	2.4	2	0.606	11	8
	5	2.41	2	0.606	11	8
	6	2.41	2			
	1	2.82	1	0.6	10.9	8
310	2	2.81	1	0.602	11	8
	3	2.82	1	0.596	10.8	8
	4	2.78	1	0.594	10.8	8
	5	2.78	1	0.594	10.8	8
	6	2.79	1			
	1	2.7	1	0.659	12	8
311	2	2.7	1	0.66	12	8
	3	2.69	1	0.629	11.4	8
	4	2.57	2	0.629	11.4	8
	5	2.57	2	0.627	11.4	8
	6	2.56	2			
	1	2.27	3	0.665	12.1	8
312	2	2.28	3	0.664	12.1	8
	3	2.28	3	0.664	12.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	4	2.28	3	0.664	12.1	8
	5	2.28	3	0.664	12.1	8
	6	2.26	3			
313	1	1.62	4	0.472	8.5	8
	2	1.63	4	0.472	8.5	8
	3	1.63	4	0.472	8.5	8
	4	1.63	4	0.472	8.5	8
	5	1.62	4	0.472	8.5	8
	6	1.63	4			
314	1	1.58	4	0.532	9.7	8
	2	1.58	4	0.532	9.7	8
	3	1.58	4	0.543	9.9	8
	4	1.61	4	0.543	9.9	8
	5	1.61	4	0.543	9.9	8
	6	1.62	4			
315	1	1.92	4	0.491	8.9	8
	2	1.94	4	0.491	8.9	8
	3	1.94	4	0.489	8.9	8
	4	1.93	4	0.489	8.9	8
	5	1.92	4	0.491	8.9	8
	6	1.93	4			
316	1	1.67	4	0.449	8.2	8
	2	1.69	4	0.448	8.1	8
	3	1.67	4	0.452	8.2	8
	4	1.69	4	0.45	8.2	8
	5	1.71	4	0.45	8.2	8
	6	1.7	4	0.452	8.2	8
	7	1.72	4			
317	1	1.51	4	0.491	8.9	8
	2	1.5	4	0.492	8.9	8
	3	1.52	4	0.497	9	8
	4	1.53	4	0.499	9.1	8
	5	1.53	4	0.499	9.1	8
	6	1.53	4			
318	1	1.74	4	0.466	8.3	7.8
	2	1.74	4	0.466	8.3	7.8
	3	1.74	4	0.461	8.2	7.8
	4	1.71	4	0.46	8.2	7.8
	5	1.7	4	0.46	8.2	7.8

Table 6.5 (Cont'd)

Sample group number	**Sub Samples**	**MOE**	**G RADE**	**SG**	**Weight [lbs]**	**Length [ft]**
	6	1.71	4			
319	1	2.1	4	0.529	9.6	8
	2	2.1	3	0.527	9.6	8
	3	2.1	3	0.532	9.7	8
	4	2.08	4	0.527	9.6	8
	5	2.09	4	0.527	9.6	8
	6	2.09	4			
320	1	1.41	4	0.632	11.5	8
	2	1.42	4	0.632	11.5	8
	3	1.41	4	0.634	11.5	8
	4	1.42	4	0.632	11.5	8
	5	1.41	4	0.632	11.5	8
	6	1.41	4			
321	1	1.93	4	0.526	9.6	8
	2	1.93	4	0.526	9.6	8
	3	1.94	4	0.517	9.4	8
	4	1.92	4	0.516	9.4	8
	5	1.92	4	0.516	9.4	8
	6	1.91	4			
322	1	2.39	3	0.608	11	8
	2	2.39	3	0.606	11	8
	3	2.39	3	0.594	10.8	8
	4	2.35	3	0.593	10.8	8
	5	2.35	3	0.593	10.8	8
	6	2.34	3			
323	1	2.22	3	0.626	11.4	8
	2	2.22	3	0.626	11.4	8
	3	2.21	3	0.614	11.2	8
	4	2.17	3	0.613	11.1	8
	5	2.17	3	0.614	11.2	8
	6	2.17	3			
324	1	2.65	1	0.622	11.3	8
	2	2.66	1	0.622	11.3	8
	3	2.66	1	0.61	11.1	8
	4	2.6	1	0.609	11.1	8
	5	2.6	2	0.609	11.1	8
	6	2.6	2			
325	1	2	4	0.699	12.7	8
	2	2	4	0.699	12.7	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2	4	0.661	12	8
	4	1.91	4	0.66	12	8
	5	1.9	4	0.66	12	8
	6	1.91	4			
326	1	2.24	3	0.61	11.1	8
	2	2.24	3	0.611	11.1	8
	3	2.24	3	0.61	11.1	8
	4	2.24	3	0.612	11.1	8
	5	2.24	3	0.61	11.1	8
	6	2.23	3			
327	1	1.39	4	0.568	10.3	8
	2	1.38	4	0.567	10.3	8
	3	1.39	4	0.555	10.1	8
	4	1.36	4	0.554	10.1	8
	5	1.35	4	0.555	10.1	8
	6	1.37	4			
328	1	1.47	4	0.564	10.3	8
	2	1.46	4	0.564	10.3	8
	3	1.47	4	0.563	10.2	8
	4	1.47	4	0.564	10.3	8
	5	1.46	4	0.563	10.2	8
	6	1.46	4			
329	1	2.12	3	0.525	9.6	8
	2	2.11	3	0.525	9.6	8
	3	2.12	3	0.526	9.6	8
	4	2.12	3	0.525	9.6	8
	5	2.11	3	0.525	9.6	8
	6	2.12	3			
330	1	1.95	4	0.523	9.5	8
	2	1.95	4	0.523	9.5	8
	3	1.95	4	0.542	9.8	8
	4	2.03	4	0.542	9.8	8
	5	2.04	4	0.541	9.8	8
	6	2.02	4			
331	1	1.58	4	0.492	8.9	8
	2	1.58	4	0.492	8.9	8
	3	1.59	4	0.507	9.2	8
	4	1.63	4	0.508	9.2	8
	5	1.64	4	0.507	9.2	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	1.63	4			
332	1	2.04	4	0.512	9.3	8
	2	2.05	4	0.512	9.3	8
	3	2.05	4	0.524	9.5	8
	4	2.12	3	0.523	9.5	8
	5	2.11	3	0.523	9.5	8
	6	2.12	3			
333	1	1.81	4	0.5	9.1	8
	2	1.81	4	0.5	9.1	8
	3	1.82	4	0.517	9.4	8
	4	1.9	4	0.519	9.4	8
	5	1.9	4	0.517	9.4	8
	6	1.91	4			
334	1	1.82	4	0.497	9	8
	2	1.81	4	0.498	9.1	8
	3	1.83	4	0.477	8.7	8
	4	1.74	4	0.478	8.7	8
	5	1.73	4	0.477	8.7	8
	6	1.74	4			
335	1	2.13	3	0.569	10.4	8
	2	2.11	3	0.57	10.4	8
	3	2.12	3	0.573	10.4	8
	4	2.18	3	0.573	10.4	8
	5	2.17	3	0.57	10.4	8
	6	2.15	3			
336	1	1.82	4	0.598	10.9	8
	2	1.81	4	0.598	10.9	8
	3	1.82	4	0.596	10.8	8
	4	1.75	4	0.598	10.9	8
	5	1.82	4	0.6	10.9	8
	6	1.82	4			
337	1	1.82	4	0.643	11.7	8
	2	1.81	4	0.641	11.7	8
	3	1.81	4	0.648	11.8	8
	4	1.82	4	0.645	11.7	8
	5	1.81	4	0.646	11.8	8
	6	1.81	4			
338	1	2.48	2	0.61	11.1	8
	2	2.47	2	0.611	11.1	8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	3	2.48	2	0.601	10.9	8
	4	2.51	2	0.601	10.9	8
	5	2.51	2	0.601	10.9	8
	6	2.51	2			
339	1	2.5	2	0.6	10.9	8
	2	2.51	2	0.601	10.9	8
	3	2.5	2	0.6	10.9	8
	4	2.5	2	0.601	10.9	8
	5	2.51	2	0.601	10.9	8
	6	2.51	2			
340	1	2.21	3	0.616	11.2	8
	2	2.21	3	0.616	11.2	8
	3	2.22	3	0.626	11.4	8
	4	2.18	3	0.626	11.4	8
	5	2.2	3	0.625	11.3	8
	6	2.19	3			
341	1	2.39	3	0.552	10	8
	2	2.39	3	0.551	10	8
	3	2.4	3	0.543	9.9	8
	4	2.37	3	0.542	9.8	8
	5	2.38	3	0.543	9.9	8
	6	2.38	3			
342	1	2.15	3	0.532	9.7	8
	2	2.17	3	0.532	9.7	8
	3	2.17	3	0.522	9.5	8
	4	2.11	3	0.521	9.5	8
	5	2.12	3	0.521	9.5	8
	6	2.12	3			
343	1	2.54	2	0.568	10.1	7.8
	2	2.54	2	0.568	10.1	7.8
	3	2.52	2	0.574	10.2	7.8
	4	2.59	2	0.574	10.2	7.8
	5	2.6	1	0.574	10.2	7.8
	6	2.6	1			
344	1	1.98	4	0.519	9.2	7.8
	2	1.97	4	0.521	9.2	7.8
	3	1.99	4	0.536	9.5	7.8
	4	2.08	4	0.538	9.5	7.8
	5	2.07	4	0.536	9.5	7.8

Table 6.5 (Cont'd)

Sample group number	Sub Samples	MOE	G RADE	SG	Weight [lbs]	Length [ft]
	6	2.07	4			
345	1	1.98	4	0.544	9.6	7.8
	2	1.99	4	0.544	9.6	7.8
	3	1.99	4	0.544	9.6	7.8
	4	1.98	4	0.544	9.6	7.8
	5	1.99	4	0.544	9.6	7.8
	6	1.99	4	0.544	9.6	7.8

APPENDIX F

MFL and MOR values of 30 samples with 40% GLSL

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
1	GLU 40% of salvaged lumber samples -1	81.28	165.1	13,831.14	38.28	2,455.23	25,167.52
2	GLU 40% of salvaged lumber samples -2	81.28	165.1	13,737.93	31.14	2,438.69	-----
3	GLU 40% of salvaged lumber samples -3	81.28	165.1	12,264.25	42.41	2,177.09	11,863.28
4	GLU 40% of salvaged lumber samples -4	81.28	165.1	12,219.87	27.68	2,169.21	-----
5	GLU 40% of salvaged lumber samples -5	81.28	165.1	12,663.75	44.37	2,248.00	-----
6	GLU 40% of salvaged lumber samples -6	81.28	165.1	10,821.68	37.32	1,921.01	-----
7	GLU 40% of salvaged lumber samples -7a	81.28	165.1	15,038.48	32.18	2,669.55	49,104.59
8	GLU 40% of salvaged lumber samples -8a	81.28	165.1	12,521.70	27.28	2,222.79	42,459.98
9	GLU 40% of salvaged lumber samples -9	81.28	165.1	13,231.90	37.79	2,348.86	32,618.63
10	GLU 40% of salvaged lumber samples -10	81.28	165.1	12,295.33	41.49	2,182.60	16,253.94
11	GLU 40% of salvaged lumber samples -11	81.28	165.1	13,120.94	37.51	2,329.16	36,656.09
12	GLU 40% of salvaged lumber samples -12	81.28	165.1	12,348.60	35.55	2,192.06	20,267.13
13	GLU 40% of salvaged lumber samples -13	81.28	165.1	14,647.86	44.25	2,600.21	28,871.29
14	GLU 40% of salvaged lumber samples -14	81.28	165.1	16,982.65	36.69	3,014.67	30,165.05

Table 6.6 MFL and MOR values of 40% GLSL

Table 6.6 (Cont'd)

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
15	GLU 40% of salvaged lumber samples -15	81.28	165.1	12,712.56	30.21	2,256.67	35,301.34
16	GLU 40% of salvaged lumber samples -16	81.28	165.1	13,316.23	34.76	2,363.83	47,014.84
17	GLU 40% of salvaged lumber samples -17	81.28	165.1	11,807.08	32.92	2,095.93	27,924.39
18	GLU 40% of salvaged lumber samples -18	81.28	165.1	12,384.09	37.89	2,198.36	40,085.28
19	GLU 40% of salvaged lumber samples -19	81.28	165.1	14,678.93	38.81	2,605.73	44,588.70
20	GLU 40% of salvaged lumber samples -20	81.28	165.1	12,552.77	31.24	2,228.30	37,251.85
21	GLU 40% of salvaged lumber samples -21	81.28	165.1	12,588.28	41.99	2,234.61	35,098.21
22	GLU 40% of salvaged lumber samples -22	81.28	165.1	15,189.39	44.96	2,696.34	35,046.22
23	GLU 40% of salvaged lumber samples -23	81.28	165.1	13,564.80	38.53	2,407.95	11,864.54
24	GLU 40% of salvaged lumber samples -24	81.28	165.1	12,876.80	32.41	2,285.82	33,770.04
25	GLU 40% of salvaged lumber samples -25	81.28	165.1	11,274.42	40.3	2,001.38	32,174.43
26	GLU 40% of salvaged lumber samples -26	81.28	165.1	13,751.24	32.27	2,441.05	38,789.92
27	GLU 40% of salvaged lumber samples -27	81.28	165.1	10,639.68	40.83	1,888.70	23,878.44
28	GLU 40% of salvaged lumber samples -28	81.28	165.1	10,724.01	23.64	1,903.67	18,247.66
29	GLU 40% of salvaged	81.28	165.1	13,143.12	22.09	2,333.10	24,852.85

Table 6.6 (Cont'd)

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
	lumber samples 21						
30	GLU V3-22	81.28	165.1	13,267.42	39.73	2,355.16	18,299.38

APPENDIX G

MFL and MOR values of 30 samples with 60% GLSL

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
1	GLU 60% of salvaged lumber samples 1	81.28	165.1	7,408.28	10.66	1,315.98	41,530.16
2	GLU 60% of salvaged lumber samples -2	81.28	165.1	13,356.13	25.52	2,370.92	29,514.55
3	GLU 60% of salvaged lumber samples -3	81.28	165.1	13,441.90	35.79	2,348.86	32,688.63
4	GLU 60% of salvaged lumber samples -4	81.28	165.1	19,653.65	41.97	3,410.23	33,171.34
5	GLU 60% of salvaged lumber samples -5	81.28	165.1	10,058.19	33.14	1,785.48	20,056.53
6	GLU 60% of salvaged lumber samples -6	81.28	165.1	13,789.24	34.69	2,145.67	27,987.34
7	GLU 60% of salvaged lumber samples -7	81.28	165.1	11,334.59	33.88	2,178.71	43,083.21
8	GLU 60% of salvaged lumber samples 8	81.28	165.1	17,620.52	30.16	3,233.34	22,150.34
9	GLU 60% of salvaged lumber samples 9	81.28	165.1	13,706.84	40.86	2,433.17	25,030.11
10	GLU 60% of salvaged lumber samples -10	81.28	165.1	13,045.48	34.75	2,315.77	3,635.89
11	GLU 60% of salvaged lumber samples -11	81.28	165.1	19,361.81	44.68	3,437.01	34,889.79
12	GLU 60% of salvaged lumber samples -12	81.28	165.1	12,748.07	38.31	2,262.97	41,959.63
13	GLU 60% of salvaged lumber samples -13	81.28	165.1	13,089.86	28.33	2,323.64	21,362.41
14	GLU 60% of salvaged lumber samples -14	81.28	165.1	14,989.65	40.01	2,660.88	-----
15	GLU 60% of salvaged lumber samples -15	81.28	165.1	14,088.57	40.2	2,500.93	-----
16	GLU 60% of salvaged lumber samples -16	81.28	165.1	17,666.21	46.33	3,136.01	-----
17	GLU 60% of salvaged lumber samples -17	81.28	165.1	10,111.46	26.24	1,794.93	35,534.36
18	GLU 60% of salvaged lumber samples -18	81.28	165.1	12,583.85	33.43	2,233.82	32,867.77

Table 6.7 MFL values of 60% of GLSL

Table 6.7 (Cont'd)

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm) (psi)
19	GLU 60% of salvaged lumber samples -19	81.28	165.1	12,441.81	31.65	2,208.60	7,376.61
20	GLU 60% of salvaged lumber samples -20	81.28	165.1	13,023.28	35.03	2,311.82	37,410.36
21	GLU 60% of salvaged lumber samples -21	81.28	165.1	12,650.43	36.54	2,245.64	26,337.79
22	GLU 60% of salvaged lumber samples -22	81.28	165.1	12,530.59	34.06	2,224.36	33,936.41
23	GLU 60% of salvaged lumber samples -23	81.28	165.1	15,704.28	42.2	2,787.74	42,975.20
24	GLU 60% of salvaged lumber samples -24	81.28	165.1	17,213.45	34.68	3,055.64	22,275.60
25	GLU 60% of salvaged lumber samples -25	81.28	165.1	14,448.13	37.92	2,564.76	2,465.52
26	GLU 60% of salvaged lumber samples -26	81.28	165.1	11,274.42	36.17	2,001.38	30,674.15
27	GLU 60% of salvaged lumber samples -27	81.28	165.1	13,356.20	35.29	2,370.92	41,680.43
28	GLU 60% of salvaged lumber samples -28	81.28	165.1	12,836.85	35.44	2,278.73	38,142.49
29	GLU 60% of salvaged lumber samples -29	81.28	165.1	14,483.62	44.53	2,571.06	39,829.63
30	GLU 60% of salvaged lumber samples -30	81.28	165.1	18,296.51	42.82	3,247.90	55,242.18

APPENDIX H

MFL and MOR values of 30 control samples

SR NO.	Specimen label	Width (mm)	Thickness (mm)	Maximum Flexure load (lbf)	Extension at Max.load (mm)	MOR (psi)	Modulus (Young's Flexure stress 2 mm - 3 mm)(psi)
1	GLU C-1	81.28	165.1	13,973.16	44.27	2,480.44	38,856.18
2	GLU C-2	81.28	165.1	11,633.95	32.27	2,065.20	40,024.09
3	GLU C-3	81.28	165.1	19,210.88	49.61	3,410.22	48,851.52
4	GLU C-4	81.28	165.1	16,396.73	44.86	2,910.66	52,556.35
5	GLU C-5	81.28	165.1	13,547.05	31.34	2,404.80	38,007.41
6	GLU C-6	81.28	165.1	12,770.28	31.58	2,266.91	42,682.83
7	GLU C-7	81.28	165.1	12,233.18	41.21	2,171.57	45,831.12
8	GLU C-8	81.28	165.1	14,403.72	44.04	2,556.87	41,810.19
9	GLU C-9	81.28	165.1	14,812.09	50.93	2,629.36	14,814.45
10	GLU C-10	81.28	165.1	14,141.84	46.86	2,510.39	51,548.98
11	GLU C-11	81.28	165.1	14,341.60	48.68	2,545.85	12,493.60
12	GLU C-12	81.28	165.1	16,920.50	32.17	3,003.64	29,050.53
13	GLU C-13	81.28	165.1	16,228.05	48.23	2,880.72	32,398.16
14	GLU C-14	81.28	165.1	15,335.86	52.6	2,722.34	11,016.72
15	GLU C-15	81.28	165.1	14,261.68	39.75	2,531.66	12,160.29
16	GLU C-16	81.28	165.1	14,860.92	39.73	2,638.03	3,486.19
17	GLU C-17	81.28	165.1	10,808.34	36.72	1,918.64	15,183.46
18	GLU C-18	81.28	165.1	16,236.93	49.99	2,882.30	46,030.36
19	GLU C-19	81.28	165.1	15,238.22	50.69	2,705.01	38,303.16
20	GLU C-20	81.28	165.1	15,304.80	33.08	2,716.83	46,398.41
21	GLU C-21	81.28	165.1	11,540.74	35.28	2,048.65	41,780.91
22	GLU C-22	81.28	165.1	11,731.61	45.54	2,082.53	11,824.33
23	GLU C-23	81.28	165.1	13,307.37	44.08	2,362.25	11,863.69
24	GLU C-24	81.28	165.1	17,355.49	43.71	3,080.86	12,160.29
25	GLU C-25	81.28	165.1	14,599.03	53.26	2,591.54	12,428.64
26	GLU C-26	81.28	165.1	16,343.46	41.76	2,901.21	22,304.56
27	GLU C-27	81.28	165.1	14,550.20	46.23	2,582.88	34,232.24
28	GLU C-28	81.28	165.1	13,391.69	53	2,377.22	37,632.86
29	GLU C-29	81.28	165.1	16,307.94	52.25	2,894.90	35,553.25
30	GLU C-30	81.28	165.1	14,141.84	46.86	2,510.39	51,548.98

Table 6.7 MFL and MOR values of 30 Control samples

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