EVALUATING THE SUITABILITY OF SALVAGED LUMBER AS FEEDSTOCK IN CROSS-LAMINATED TIMBER

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ABSTRACT

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Structural abandonment has been a growing concern in the United States for the past few decades. Conventional demolition procedures exercised to eliminate the abandoned structures result in wood waste that are not feasible for reuse. On the other hand, the demand for lumber has been steadily increasing. This research focuses on promoting deconstruction, obtaining the salvaged lumber from deconstructed abandoned buildings, and evaluating the possibility of reusing it to make way for a secondary means of lumber production.

The study evaluates the engineering properties of salvaged lumber. Furthermore, the salvaged lumber is partially used to manufacture Cross Laminated Timber (CLT) per the current standards and its properties are compared against the properties of CLT panels exclusively made of freshly sawn lumber. By developing variables for the study, the various factors affecting the properties are analyzed. The researcher believes that the intended results would inaugurate the consideration of salvaged wood usage in wood products that serve as construction material.

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Go Green!

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CHAPTER 1: INTRODUCTION

1.1 OVERVIEW

Like all other existing matter in the universe, wood has a certain life span. Researchers have tried to prove that lumber has a greater lifecycle than it is assumed to possess. The use of structural lumber, especially in residential and industrial construction, has always been high in Northern America. There has been a steady increase in the number of abandoned residential buildings in the US. As the construction industry is moving towards sustainability, the need for reusing or recycling lumber is an increasing concern among researchers. Over the years, the US government has spent millions in demolition of these unoccupied houses. Salvaged lumber obtained after demolition are not being reused but are either dumped in landfills or destroyed by incineration. The main reason for hesitance in reusing salvaged lumber is that the current lumber grading standards do not approve the usage of salvaged lumber for new construction.

There is an abundance of salvageable lumber which has high potential in various industrial-scale uses. One of such rapidly growing industries include mass timber construction. The aim of this research is to test the properties of lumber extracted from abandoned buildings, use them as feedstock for a category of mass timber called Cross Laminated Timber (CLT) and demonstrate the applicability of salvaged lumber usage by analyzing the results. This chapter explores the current trends of mass timber construction, discusses the pathbreaking concept of domicology, emphasizes the need to supplant demolition with deconstruction, takes a broader look into CLT and establishes the need and objectives of this research.

1.2 MASS TIMBER CONSTRUCTION

Mass timber is a product made of engineered wood components that are laminated and compressed to form wooden panels. Mass timber construction is a method where these wooden panels are used as the structural frame for buildings (Jones 2017). While relatively new, the concept of mass timber is no longer unfamiliar in the US. There are approximately 784 projects in the design or construction stage across the 50 states as of January 2020 (Woodworks 2020).

One of the most used mass timber products is Cross Laminated Timber (CLT). In 2015, it was included in the International Building Code (IBC), which most of the jurisdictions in the US adopt as their base standard (Roberts 2020). This change in the building code allowed the use of CLT in floors, roofs, partition walls and exterior walls. It also required structural timber such as CLTs to meet the ANSI/APA PRG 320 standards for structural performance (Wikipedia 2021). The allowance of constructing tall timber structures that go up to 13 stories has been agreed upon and will be formally executed by the new IBC code in the year 2021 (Woodworks 2020). The states in the Pacific Northwest have welcomed this concept and are enthusiastically adopting mass timber at a much faster rate. Oregon and Washington are the two states among those who have already accepted the IBC changes back in 2018.

Although most of the CLTs are imported from Canada and Europe, the United States has several manufacturers (ArchPaper 2019), including:

- SmartLam, Montana
- Freres Lumber Co., Oregon

- DR Johnson, Oregon
- International Beams, Alabama
- Bensonwood, New Hampshire
- LignaTerra Maine, Maine
- Texas CLT LLC, Arkansas
- Katerra, Washington

The market demand for the amount of lumber required to manufacture mass timber was forecasted by The BECK Group in 2018 (BECK Group 2018). According to the forecast, it was estimated that in order to produce one cubic foot of CLT, approximately 21.4 nominal board feet of lumber will be needed. In 2013, FP Innovations, a Canadian research and development organization, estimated that mass timber CLT construction would occupy 5% to 15% of the existing construction markets, with demand of lumber equivalent to approximately 180 million cubic feet (BECK Group 2018).

In 2016, Forterra, Heartland LLC, Washington State University, and University of Washington collaboratively estimated a demand of 1.2 billion cubic feet of CLT in 2020 across the Pacific Northwestern states alone. More specifically, Washington, Idaho, Oregon and Montana (BECK Group 2020).

Organizations such as WoodWorks and ThinkWood promote the use of mass timber in construction. They have been assisting architects, engineers, and builders interested in mass timber construction. WoodWorks also provides a map on the existing mass timber projects across the United States and provides live reports on the number of total projects as shown in Figure 1.1.

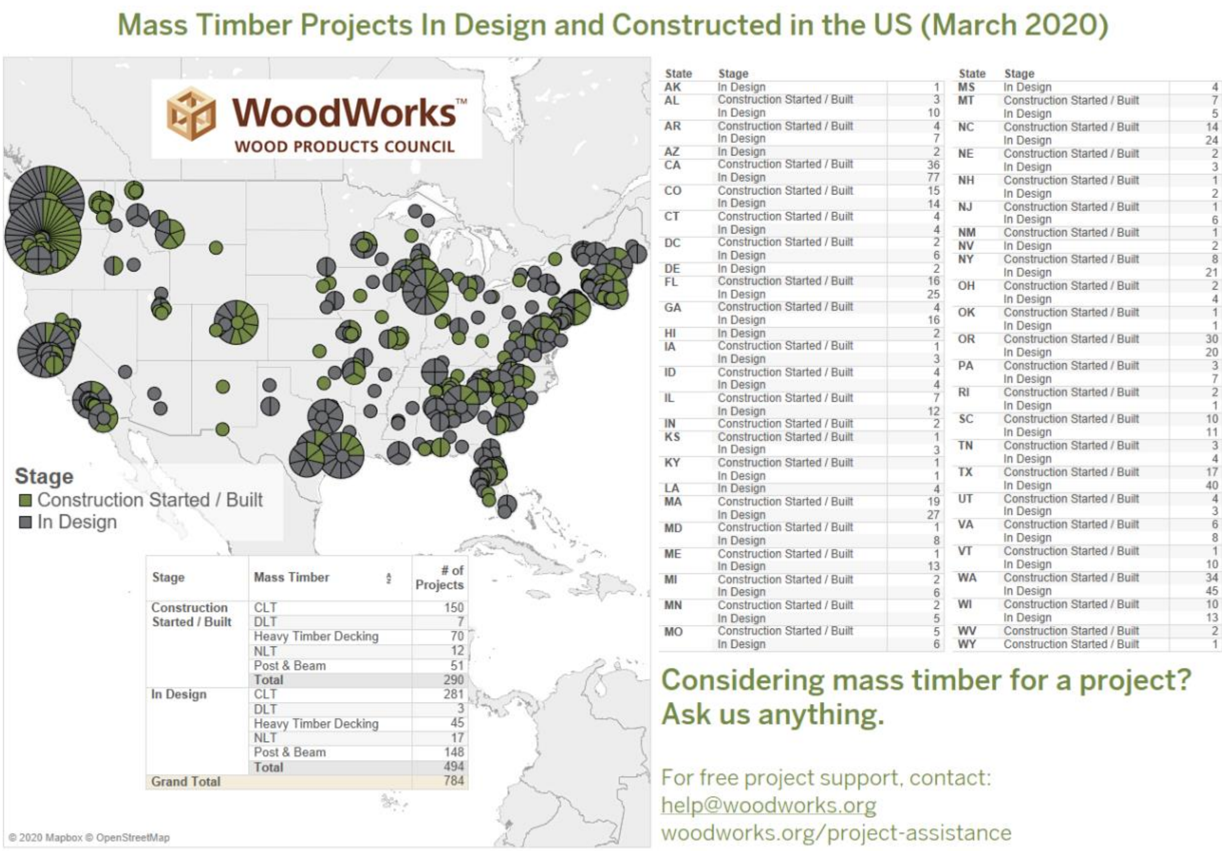

Figure 1.1: WoodWorks Mass Timber Projects Map (Source: woodworks.org)

In North America, the mass timber products industry is a new and emerging sector in the construction industry. It has gained popularity in recent years in the United States due to the following benefits:

- Cost and time savings: Due to the easier installation techniques when compared to the traditional concrete and steel structures, it saves a lot of time and also time-variable overhead costs. Additionally, transportation and labor costs are much lesser (BECK Group 2018).

- Fire safety: Mass timber products withstand a lot of heat for a long time due to the charring effect (Roberts 2020)
- Sustainability: Due to the low carbon footprint, renewability and high thermal efficiency, mass timber is a very sustainable solution in the construction market (BECK Group 2018).\

Although mass timber construction is a sustainable alternative when compared to steel and concrete construction (Roberts 2020), using reclaimed lumber as feedstock would add an additional dimension of sustainability. In the next section, the concept of Domicology is explained and, we shall see more about how reusing salvaged lumber from deconstructed abandoned buildings can contribute to eliminate blight and extend the lifecycle of timber by encouraging its use in producing CLTs.

1.3 DOMICOLOGY AND STRUCTURAL ABANDONMENT

Domicology is described as the study of the life cycle of the built environment (Berghorn et. al 2019, LaMore 2021). It is a new word coined by researchers from Michigan State University namely, Dr. Rex LaMore, Dr. George Berghorn and Dr. M.G. Matt Syal.

The concept of Domicology is to create a built environment where the structures are planned, designed, constructed and when abandoned, they are deconstructed or reused. In other words, the idea of demolition of abandoned buildings should be replaced with deconstruction so that the components can be recycled and reused. The theory placed here is that every structure has its life cycle and by deconstructing abandoned structures, the life cycle of its components can be extended and pushed into a continuous loop of reuse until it has truly exhausted its usage value. The focus of domicology is of two parts (1) to recycle the components of the existing abandoned buildings and (2) to design buildings in future that can be easily deconstructed to facilitate recycling of its components. Currently, more emphasis is being given to the former to fight the rapidly increasing blighted neighborhoods in the US, more specifically the Detroit region. One of the main reasons for such widespread abandonment of buildings was the Great Recession during the late 2000s. Structural abandonment has several negative effects on the society and the economy. The property value of surroundings neighborhoods decreases and, rates of unemployment and crime rise (LaMore 2015). Since 2014, Michigan has been funded by the Federal government to eliminate blight by various demolition programs. In 2019, $250 million was awarded to eliminate residential blight (Parker 2019).

Figure 1.2: US Census Abandoned Houses Data

According to US Census Bureau's 5-year estimate data, it can be observed that there has been a steady increase in the number of abandoned houses in the US. There are approximately 227,000 abandoned buildings in Michigan which are identified as 'other vacant'.

	MICHIGAN	
	Estimate	**Margin of Error**
Total:	671,430	±8,535
For rent	62,902	±2,230
Rented, not occupied	15,809	±1,059
For sale only	46,792	±2,036
Sold, not occupied	26,461	±1,200
For seasonal, recreational, or occasional use	290,711	±2,795
For migrant workers	1,977	±222
Other vacant	226,778	±3,956

Table 1.1: Other Vacant Data (Source: census.gov)

The objectives of the researchers associated with Domicology are to (1) identify the abandoned structures that have a life cycle; (2) analyze the built environment's life cycle to plan, design, construct and deconstruct the structures and thereby maximize reuse; (3) discover the challenges faced by a structure during the course of its life cycle and therefore find ways to eliminate the negative impacts of its abandonment; and (4) create increased job opportunities for local people affected by structural abandonments (Berghorn 2019).

This paper will be partly responsible for achieving the first two objectives. Samples of salvaged lumber were obtained from one of the 227,000 abandoned structures in Michigan to analyze their suitability for reuse. The goal of this research is to manufacture CLT panels using reclaimed lumber acquired from deconstruction of such abandoned buildings. As we have understood the benefits of mass timber products in general, the next section, specifically, will thoroughly outline the advantages of CLTs.

1.4 CROSS-LAMINATED TIMBER (CLT)

Cross laminated Timber (CLT) is a new type of building system that uses wooden panels consisting of several layers of lumber boards stacked and glued orthogonally, with each layer arranged at 90 degrees to its adjacent layers. Originally from Europe, this relatively new subset of mass timber construction has been gaining popularity in Northern America in the recent few years. CLTs are used as substitutes of concrete and steel construction due to the easier construction procedure and is a more sustainable structure. The researchers associated with Domicology encourage the mass timber construction methods using material such as CLTs. Researchers are also working on designing CLT structures in a way they can be effectively deconstructed thereby rendering most of its components for reuse. CLT has a better performance against fire and natural disasters such as earthquake.

A typical CLT panel's cross-section has at least three layers of lumber boards placed crosswise in an alternating orthogonal orientation.

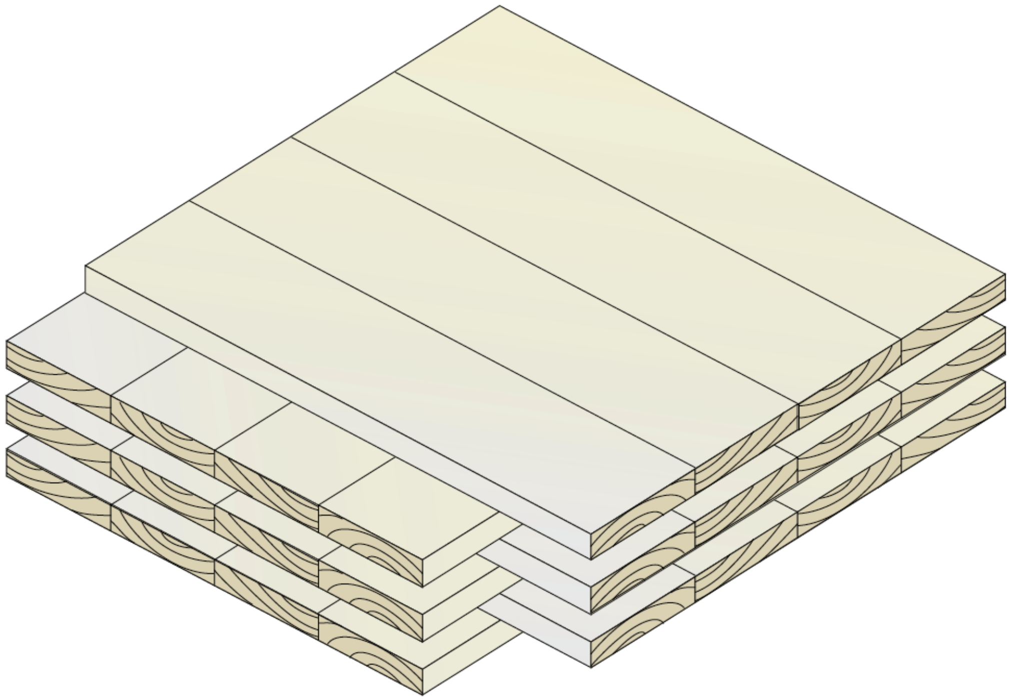

Figure 1.3: CLT Structure (Source: CLT Handbook)

CLT structures are usually assembled on site and the panels are connected using various means such as bolts, self-tapping screws, ringed shank nails etc. The panels are generally prefabricated, transported, and stored on site.

The process of manufacturing CLTs include the following steps: (1) Selection of primary lumber (2) Lumber grouping (3) Planing (4) Cutting lumber layers to length (5) Application of adhesives (6) CLT panel lay-up (7) Assembly pressing (8) Quality control, machining and cutting (9) Product marking and packaging.

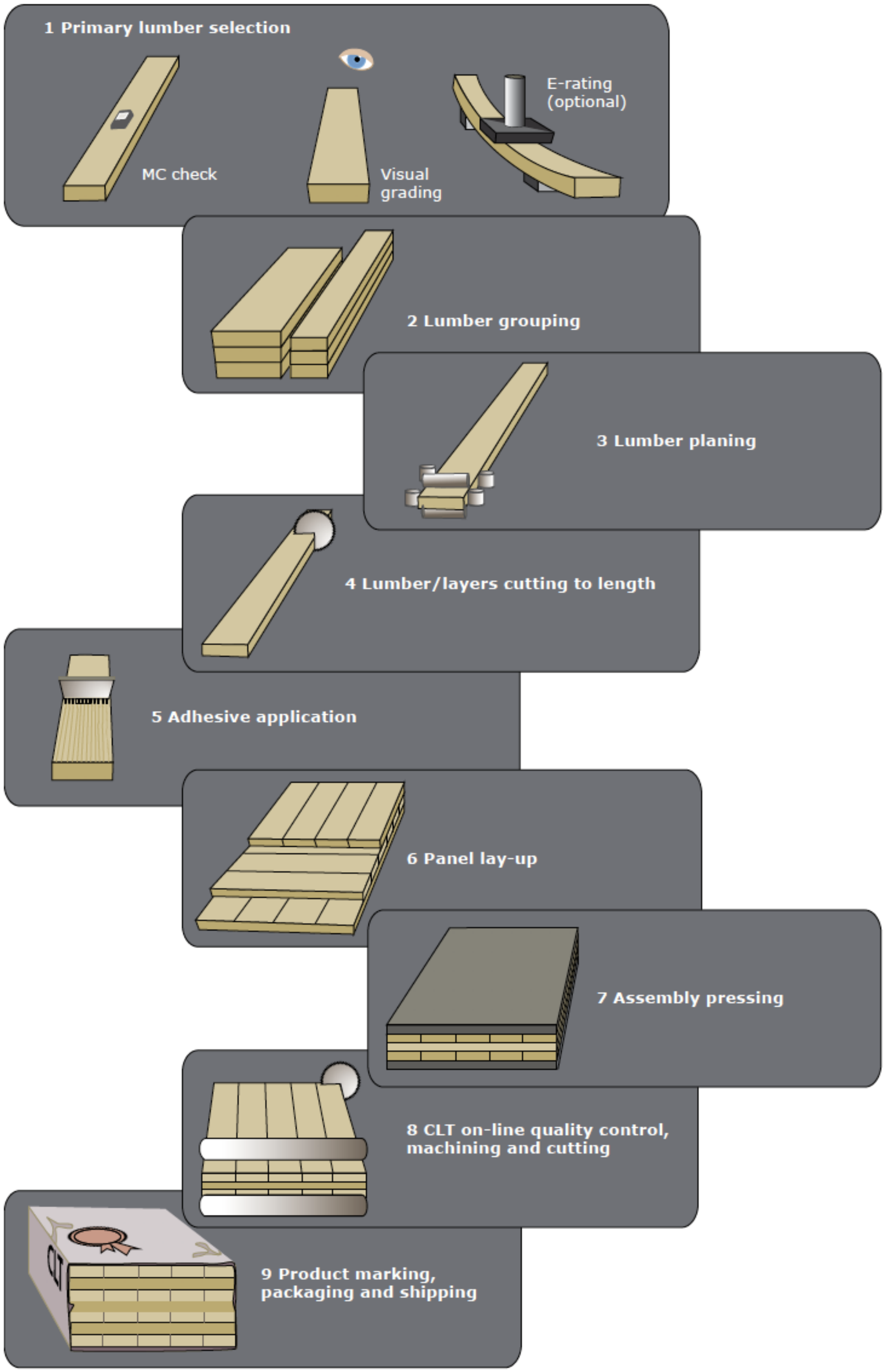

Figure 1.4: CLT Manufacturing Process (Source: CLT Handbook)

In 2011 APA- The Engineered Wood Association of United States and FP Innovations of Canada came together to create a standard for CLT products in North America called ANSI/APA PRG-320- 2011 *Standard for Performance-Rated Cross-Laminated Timber.* Nail laminated CLT and other type of CLTs without face bonds are not included in ANSI/APA PRG 320 standard.

Since the publication of the CLT standard ANSI/APA PRG 320, the commercialization of CLT products have been taking place rapidly and a continuous standard improvement is expected in the coming years (CLT Handbook 2013).

1.5 CONSTRUCTION MANAGEMENT PERSPECTIVE

1.5.1 COMMON APPLICATIONS

CLT is generally used as structural components in buildings such as floors, walls, and roofing. Some of the projects use CLT for all the structural framing above the foundation which include floors, roofs, and walls whereas some buildings only have specific components of CLT such as floor decking (Breneman 2016). Due to the high compressive force resistant properties of CLT panels, they are used as long-span diaphragms as well (Think Wood 2021).

1.5.2 COST AND TIME EFFECTIVE

The beams, columns, and panels typically weigh 1/4th or 1/5th the weight of steel and concrete materials (CD Smith 2021). This results in lesser foundation costs. Since it requires a relatively smaller crew for installation, it reduces the installation cost by up to 50 percent. This means that CLT construction has an earlier project completion date (Spickler 2014). Prefabricated panels require a crew of only 5-6 to install more than 8000 square feet per day (Bratton 2017).

1.5.3 SAFETY

Since prefabricated panels only require power tools such as pneumatic drills, the job site safety also increases significantly (Bratton 2017). CLT panels produced by North American manufacturers meet ASTM E119 standards which has a two-hour fire resistance rating. It also demonstrates superior earthquake resistance due to the lighter weight when compared to concrete and steel structures (The Hartford Staff 2021).

1.6 NEED STATEMENT AND RESEARCH QUESTION

Nearly 3 trillion board feet of lumber has been used in construction since the turn of the twentieth century (Chini 2001). The lumber obtained from the structures that reach the end of their service lives become disused due to the traditional demolition practices (Chini 2001). Structural abandonment has been an increasing concern in the United States. The US government is focused on blight removal by funding millions in demolition projects. Over 50 million tonnes of wood waste are generated as construction and demolition (C&D) waste every year (EPA 2018). The C&D waste are dumped in landfills and wood in this waste constitutes approximately 14.5 million tons, which is more than the annual timber harvest from national forests (Madhani 2018). Deconstruction is a more sustainable option when compared to demolition. This practice promotes use of the constituent wood material by extending its lifecycle when the structure itself has reached the end of its service life (Arya 2017). The lumber obtained from such abandoned structures remains one of the largest untapped sources in the United States. The researchers at Michigan State University are focused on promoting deconstruction of such blighted structures in order to salvage wood for reuse. This research aims to reuse salvaged lumber in the production of CLT.

One of the major drawbacks preventing salvaged lumber reuse in construction is the existing grading rules. The APA Engineered Wood Products developed grading rules for performance rated CLT called the ANSI/APA PRG 320-2018, which consists of seven CLT manufacturing grades. These grades can be used only to grade freshly sawn lumber and do not address the use of salvaged lumber (Falk 2002). Since this grading criteria is developed for virgin lumber, there is no guide for evaluating damage, nail holes and, splits or checks such as those present in salvaged lumber. The grade stamps on freshly sawn lumber allow them to be salable. Although current grading criteria can be used to grade salvaged lumber, the standards or the grading rules do not account for salvaged lumber (Falk 2002). Thus, there is a need for a new grading system that quantifies the damage in salvaged lumber created during construction and deconstruction. The revised grading rules should establish new grading stamps for salvaged lumber that allows them to be salable (Falk 2002). This would expand the market for reuse and thus significantly increase the economic value of salvaged material. This paper focuses on testing the properties of salvaged lumber, manufacture CLT panels using a proportion of these salvaged lumber and evaluate their performance by comparing the results against CLTs made solely using freshly sawn lumber. By analyzing the effects of damage, knots, and nail holes on the properties of the material, this research also aids in understanding how they can affect or not affect the grade. Thus, assessing the viability of having salvaged wood as a reliable construction material as the new norm.

1.7 RESEARCH GOAL AND OBJECTIVES

As mentioned earlier, this research aims to evaluate the potential of salvaged lumber in industrial-scale uses. More specifically, it focuses on extending the wood's life span by exploring the option of using it in the burgeoning mass timber products industry. The objectives of this paper and the tasks to achieve the goals are as follows:

<u>Objective 1:</u> Characterize the physical and mechanical properties of salvaged lumber from archetypical abandoned buildings in Michigan

- *<u>Step 1:</u>* Perform a literature review to be aware of the context of this research based on previous relevant work. This helps in visualization of the structure of the research by analyzing limitations and outcomes of previous research work

- *<u>Step 2:</u>* Develop characteristics of interest as variables for the study based on the literature review and the availability of samples. In this case, the variables of study are the factors that influence or affect the properties of the salvaged lumber and the manufactured CLT panels

- *<u>Step 3:</u>* Collect lumber samples from the site and transport to the lab for testing

- *Step 4:* Classify the samples based on the developed variables using a coding system to help identify the samples based on the classification. In other words, it aids in tracking the properties of the individual lumber pieces when analyzing the properties of the final product i.e., the CLT panels

- *Step 5:* Evaluate physical and mechanical properties of the samples, to include specific gravity, modulus of rupture (MOR) and modulus of elasticity (MOE) of the salvaged lumber

Objective 2: Manufacture CLT panels using the salvaged lumber and test their properties

- *Step 6:* Develop comparison groups considering the variables of interest to manufacture CLT panels as a combination of these factors namely, properties of the salvaged lumber and position of the salvaged lumber in the layup

- *Step 7:* Manufacture CLT panels as a combination of the salvaged lumber and virgin lumber in accordance with the ANSI/APA PRG 320-2018 standards. Manufacture another batch of CLT panels solely using freshly sawn lumber

- *Step 8:* Subject the manufactured panels to 3-point bending tests to record its MOE and MOR values

Objective 3: Demonstrate the applicability of using salvaged lumber in CLTs by statistically analyzing the results of the comparison groups

- *Step 9:* Compare the performance of the CLT panels that comprises of salvaged lumber against the CLT panels that are exclusively made of virgin lumber

- *Step 10:* Analyze the results and evaluate the effect of the variables on the properties of the CLT panels.

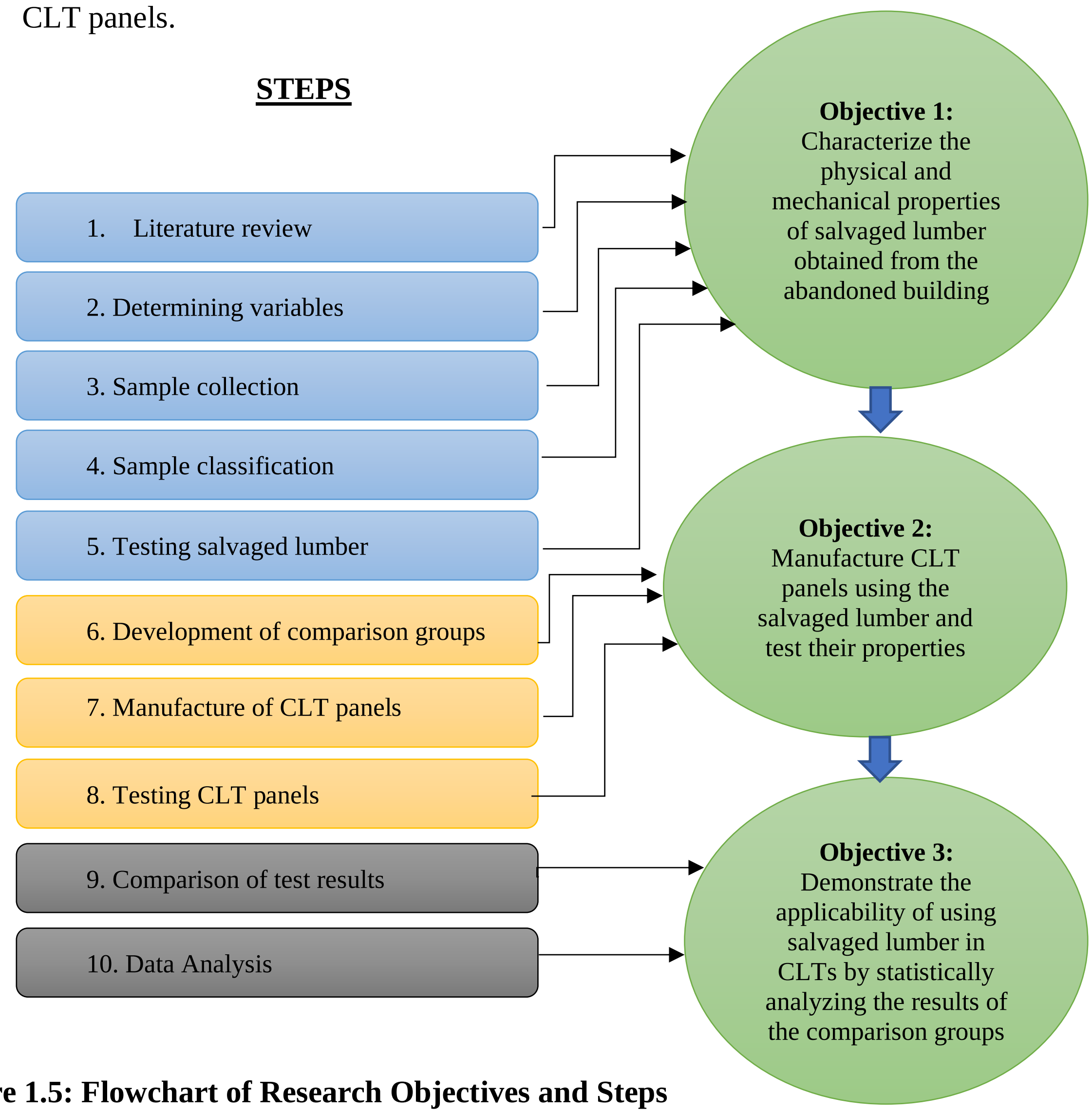

Figure 1.5: Flowchart of Research Objectives and Steps

1.8 SCOPE AND LIMITATIONS

The sample size for this research was determined based on the availability of deconstruction projects with collected salvaged lumber in Michigan. The samples were obtained from a single abandoned house in Bay City, Michigan which was approximately 60 years old. The majority of the samples were of Southern Yellow Pine species. Due to the COVID-19 pandemic, the availability of projects was restricted, and the transportation of samples from the site to the lab were delayed. The research laboratory was also shut down for five months as a precaution for the spread of the novel coronavirus. 68 samples of 2 x 12 dimensions and approximately 15 feet in length were tested on the Metriguard 340-E. Following are the drawbacks of using the Metriguard instrument:

- The setup consisted of two tripods where the samples were placed flatwise. One of the tripods consisted of a load-cell and the other had a knife-edge. The knife-edge could not handle the large wooden members, and this caused bending of the knife-edge. The samples were placed with caution to avoid any damage to the instrument.
- The setup also required connecting the load-cell to the user interface using a wire. Any change in the tightness of the connection would affect the accuracy of the data. Care was taken during calibration of the load-cell to prevent inaccuracy
- The minimum length requirement for sample of 2-inch thickness was 69 inches. Thus, the smaller samples could not be tested for MOE using the Metriguard

Due to limited sample size and to maintain accuracy of the data, the 68 samples were cut into 6 parts each and were then tested both on the Metriguard and the Instron 4206. The year of production of the lumber samples could not be determined since there were no records of the mill that manufactured the members. The scope of this research is limited only to the use of salvaged lumber in the production of CLTs.

1.9 RESEARCH OUTCOMES AND FUTURE SCOPE

The primary aim of this research is to compare the performance of CLT panels manufactured using a proportion salvaged lumber against that of the panels produced solely using virgin lumber. Over the years, researchers have promoted the idea of developing an amended grading standard that incorporates the evaluation of salvaged lumber. The data from this research could be used to develop such a grading standard. The samples are mostly of Southern Yellow Pine species. Future researchers can compare this data with similar research conducted using other hardwood or softwood species.

CHAPTER 2: LITERATURE REVIEW

2.1 OVERVIEW

This chapter provides a synopsis of the relevant literature that has been studied for the purpose of this research. The aim of this review is to develop a greater understanding of the context of this research and to be equipped with the fundamental knowledge of the area of interest. It is divided into four parts and explores the topics of (1) trends in lumber consumption for construction in the United States, (2) construction wood waste recovery, (3) existing CLT grading standards and, (4) previous research conducted on properties of salvaged lumber. The following diagram illustrates the outline of this chapter.

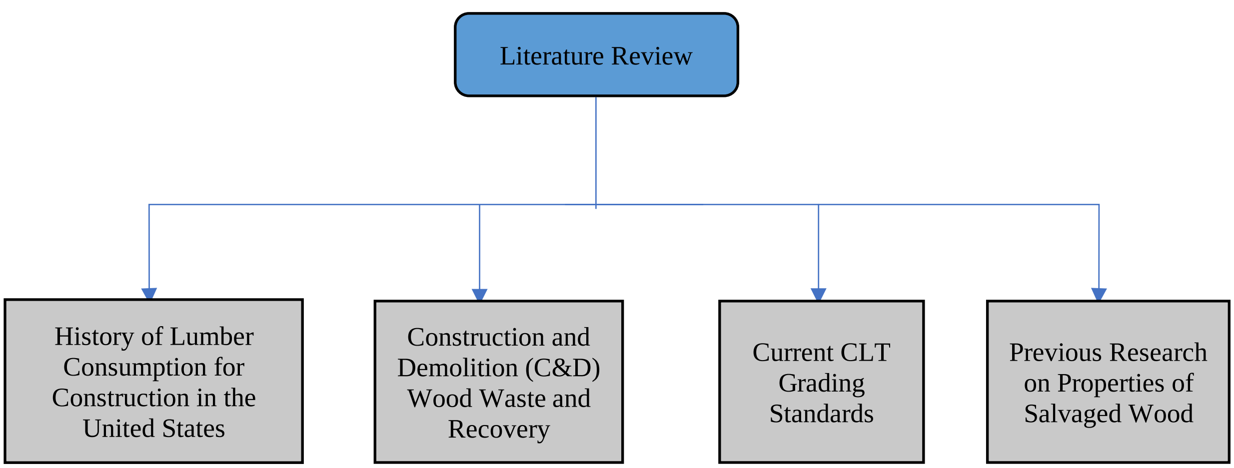

Figure 2.1: Literature Review Outline

The first section provides the background about lumber consumption over the years in the United States. It describes the state of lumber demand and price trends followed by the Great Recession and the COVID-19 pandemic. By analyzing the same, it establishes the foundation for a need to find an alternative source of lumber that is environment friendly. The second section emphasizes on the amount of wood waste being generated due to demolition. It provides a base for considering deconstruction as time and cost-efficient way of reusing wood waste. Moreover, it glances into the huge potential of the mass timber market in the United States. The third section equips us with the understanding of the existing CLT grading criteria for freshly sawn lumber as feedstock. The final section furnishes information of previous research work on the mechanical and physical properties of lumber salvaged from old structures. It anatomizes the various factors that affect these properties and thus serves as a cornerstone for the methodology of this research.

2.2 HISTORY OF LUMBER CONSUMPTION FOR CONSTRUCTION IN THE UNITED STATES

Construction has the largest market for lumber consumption in the United States. McKeever and Howard (2011) published a report which mentions that in 2009, around 60% of the solid wood timber products were consumed for construction and remodeling of housing units, commercial buildings and other non-residential buildings. This report also states that about 7,026 billion bf of lumber was used in new residential construction of which an average single-family house required approximately 13,600 bf of lumber.

When it comes to lumber species, it can be sorted into two main categories namely, hardwood and softwood. Softwood species constituted 83% of lumber consumption (McKeever and Howard 2011). The majority of the hardwood consumption in the United States until the early 1980s belonged to the furniture market (Luppold and Bumgardner 2008). The increasing dominance of imported furniture from the late 1980s caused the decline of hardwood lumber consumption in the furniture production (Buehlmann et al 2017). Since then, almost twice the amount of hardwood lumber was then used for residential construction (Luppold and Bumgardner 2008). Lumber prices reached its peak in 2004 followed by an economic recession in the late 2000s that led to the decline in hardwood lumber demand and consequentially resulting in a steady decline in prices (Luppold et al 2014). However, there was a significant increase in the export of hardwood lumber from the US. Buehlmann et al (2017) proclaims that the construction of multi-family homes rose post-recession due to the lower value when compared to single-family homes.

Wood products usage has also been significantly high in the non-residential market. Adair et al's (2011) studies showed that about more than a quarter of the non-residential buildings used wood products, mainly softwood, as the fundamental structural material. In 2011, even after the economic recession, it was calculated that about 3.8 bf of lumber was used in the construction of non-residential buildings of which a significant portion belonged to low-rise buildings (Adair et al 2011).

In a report published by Alderman (2020), it is stated that new house construction increased by 4.2 percent from the year 2019 to 2020. More specifically, single-family house units increased by 1.4 percent. The market share for softwood in housing construction had increased by 11.5 percent in the last decade, whereas hardwood lumber production had fallen from 2018 to 2020 (Alderman 2020). According to this report, there had been a steady increase in lumber prices since the beginning of the COVID-19 pandemic. In the year 2020, softwood framing lumber prices increased by an astonishing 172 percent in 5 months period (Alderman 2020). As a result of increasing lumber prices, building a new home proved to be more expensive. Although the demand for softwood lumber was high throughout the year due to the boom in housing market, sawmills anticipated a slump in demand and had decreased their second quarter production (Alderman 2020). This decision to curtail production was due to the decline in housing starts in the year 2019. Furthermore, social distancing rules exacerbated the low supply situation since the mills had to limit working shifts (Olick 2021). During the March of 2021, lumber prices increased by 300 percent since the start of the COVID-19 pandemic (NAHB 2021).

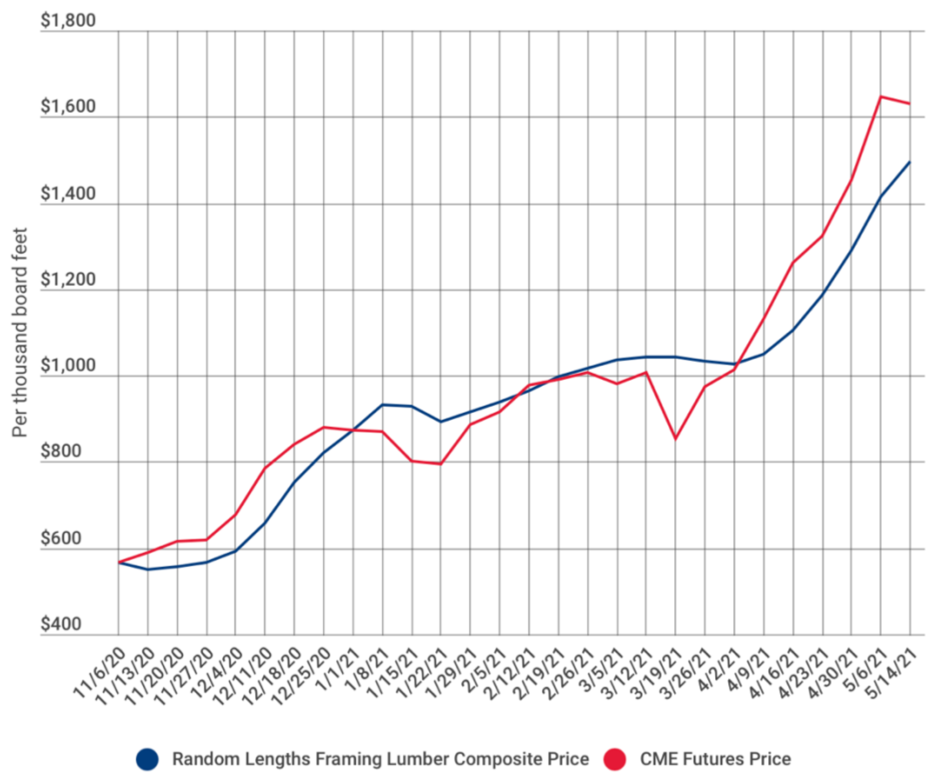

Figure 2.2: Lumber Prices (Source: NAHB, 2021)

In recent years, there has been innovation in wood products such as the concept of Cross Laminated Timber (CLT). Although CLT is predominantly manufactured using softwood lumber, hardwoods can also be used to make these panels (Crespell and Gagnon 2010). The North American Mass Timber (2020) report predicts that the amount of mass timber projects will double every two years. It also states that nearly 13 billion board feet of lumber would be required for such projects by the year 2034. This report projected that the manufacturers need to increase their rate of production by nearly 40 times the current rate in order to meet the demand of timber panels. The streaming of salvaged lumber into the market would alleviate the pressure placed of lumber manufacturers and would in turn serve as a sustainable option.

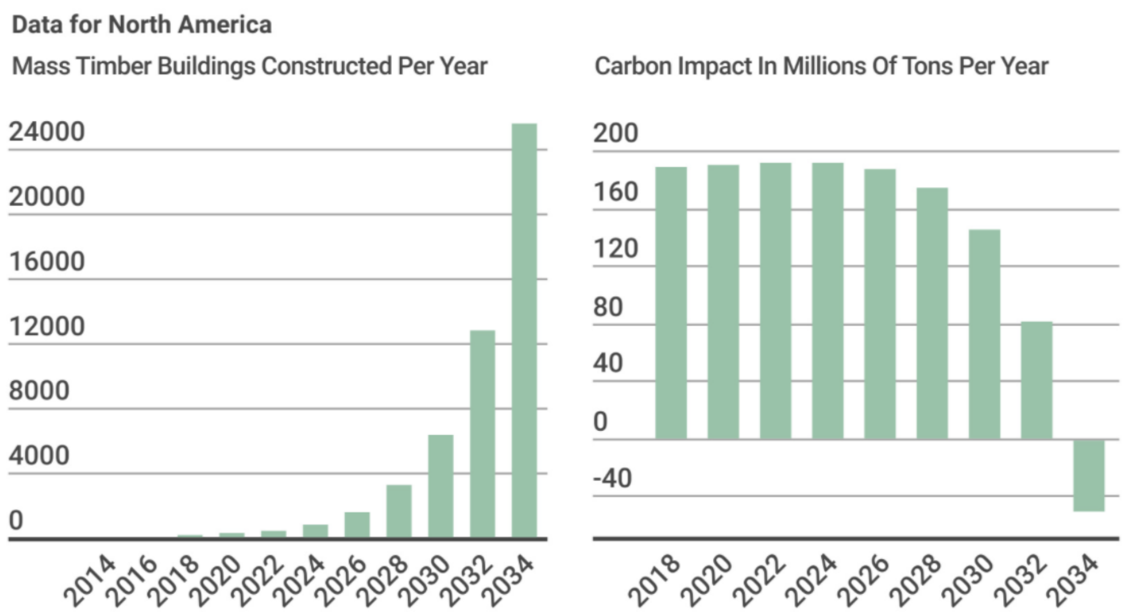

Figure 2.3: Trends in Mass Timber Projects (Source: The Mass Timber Report 2020)

2.3 C&D WOOD WASTE AND RECOVERY

Although construction and demolition are two different activities, Construction and Demolition (C&D) waste is treated as a single source since both are deposited in landfills (Falk and McKeever 2004). The waste produced during construction, remodeling and repair of structures is known as construction waste (Falk and McKeever 2012). Whereas the waste generated as a result of demolishing structures or buildings forms the demolition waste. The primary focus of this research is on the latter and more specifically on wood waste. Wood accounts for 33 percent of the C&D waste (Diyamandoglu and Fortuna, L. M. 2015). According to an article by Falk and McKeever (2012), about 36.4 million tons of wood waste was generated in 2010. The article also mentioned that over 80 percent of them constituted demolition waste. The wood from demolition waste is difficult to recover since the debris is usually contaminated during the process and almost all of them are rejected. According to a few case studies in 1990, as mentioned by Falk and McKeever (2004), the recovery rate for demolition waste wood is about 30 percent which was calculated to be 10.6 million metric tons in 2002.

	Waste Generated (million tons)	Not Available for Further Recovery (1)	Available for Further Recovery
Wood Waste Source			
MSW (2)	14.2	7.7	6.5
Construction (3)	11.6	3.0	8.6
Demolition (4)	29.4	17.1	12.3
TOTAL	55.2	27.8	27.4

(1) Recovered, combusted, or not usable.
(2) 2007 estimate.
(3) Based on 2002 data.
(4) Based on January 2009 U.S. population estimate.

Table 2.1: Wood Waste Generated (Source: Bratkovich, 2009)

It can be understood that a large chunk of wood waste is discarded due to contamination and the recovered wood can be used in value-added products only if they form a clean feedstock. Deconstruction is the alternative method to avoid such low recovery rates. Deconstruction is a procedure in which the structures are disassembled. This method promotes wood reuse since the salvaged material's properties are preserved. Lumber extracted from deconstruction are usually of old-growth harvest which are of higher structural properties than modern day lumber (Falk and McKeever 2004). Recycling lumber obtained from C&D waste has gained attention in the United States due to the great environmental and economic impacts (Peng et al. 1997). Reusing is a more energy efficient strategy when compared to recycling. The material that is recycled consumes more energy to be processed than it takes to manufacture virgin material. Deconstruction reduces the Green House Gas (GHG) emissions due to the avoidance energy consumed for transportation and disposal of waste (Diyamandoglu and Fortuna, L. M. 2015).

2.4 CURRENT CLT GRADING STANDARDS

The characteristics of lumber sawn from trees regardless of their size vary in mechanical properties. To make it more economical, lumber is categorized into stress classes based on their mechanical properties (Kretschmann and Green 1999). The PRG 320 classifies the grades of CLT into seven stress classes based on the lumber characteristics and the species of wood. Four of the CLT grades are made of lumber that are machine graded (E1, E2, E3 and E4) and three of them use visually graded lumber (V1, V2 and V3).

Machine graded lumber can be divided into three main categories namely, Machine Stress Rated (MSR) lumber, Machine Evaluated Lumber (MEL) and E-rated lumber. The PRG 320 stress classes are based on MSR lumber grading criteria. In this process, the lumber is tested using non-destructive methods in which the evaluation is done by a mechanical stress rating equipment. The grades are designated by using the design values such as the allowable stress in bending (F_b) and the edgewise modulus of elasticity (E). For example, the E1 stress class has a grade of 1950f-1.7E, which designates a grade with an allowable stress of 1950 lb/in^2 and an E value of 1.7 X 10^6 lb/in^2. Although it is termed as mechanically graded, the lumber should also satisfy certain visual requirements before the product is labeled (SPIB 2021).

Visual grading is done by sorting the stress classes based on growth characteristics such as knots, checks and splits, shake, slope of grain and wane. The location and size of a knot has various effects on the bending strength of the lumber, especially in tension. Due to the fibers not being parallel to the edges, higher slope of grain lowers the mechanical properties of lumber. Checks and splits are separation of wood caused by seasoning and rupturing of wood cells. The weakness in bonding between annual rings cause shakes that affect the shear stress of the wood (Kretschmann and Green 1999). According to the National Grading Rule for Dimensional Lumber published by the American Lumber Standards Committee (ALSC), structural light framing lumber can be classified into four grades namely, Select Structural, No.1, No. 2 and No.3.

The CLT stress classes for North America based on lumber grades and layups mentioned in the PRG 320 are as follows:

- **E1:** 1950f-1.7E Spruce-pine-fir MSR lumber in all longitudinal layers and No. 3 Spruce-pine-fir lumber in all transverse layers
- **E2:** 1650f-1.5E Douglas fir-Larch MSR lumber in all longitudinal layers and No. 3 Douglas fir-Larch lumber in all transverse layers
- **E3:** 1200f-1.2E Eastern Softwoods, Northern Species, or Western Woods MSR lumber in all longitudinal layers and No. 3 Eastern Softwoods, Northern Species, or Western Woods lumber in all transverse layers
- **E4:** 1950f-1.7E Southern pine MSR lumber in all longitudinal layers and No. 3 Southern pine lumber in all transverse layers
- **V1**: No. 2 Douglas fir-Larch lumber in all longitudinal layers and No. 3 Douglas fir-Larch lumber in all transverse layers
- **V2:** No. 1/No. 2 Spruce-pine-fir lumber in all longitudinal layers and No. 3 Spruce-pine-fir lumber in all transverse layers
- **V3:** No. 2 Southern pine lumber in all longitudinal layers and No. 3 Southern pine lumber in all transverse layers

The PRG 320 mentions that custom CLT layups are also allowed upon acceptance from an approved agency. The design values for laminations used in the CLT grades are illustrated in the tables below:

CLT Grades	Laminations in the Major Strength Direction of the CLT						Laminations in the Minor Strength Direction of the CLT					
	$f_{b,0}$ (psi)	E_0 (10^6 psi)	$f_{t,0}$ (psi)	$f_{c,0}$ (psi)	$f_{v,0}$ (psi)	$f_{s,0}$ (psi)	$f_{b,90}$ (psi)	E_{90} (10^6 psi)	$f_{t,90}$ (psi)	$f_{c,90}$ (psi)	$f_{v,90}$ (psi)	$f_{s,90}$ (psi)
E1	4,095	1.7	2,885	3,420	425	140	1,050	1.2	525	1,235	425	140
E2	3,465	1.5	2,140	3,230	565	190	1,100	1.4	680	1,470	565	190
E3	2,520	1.2	1,260	2,660	345	115	735	0.9	315	900	345	115
E4	4,095	1.7	2,885	3,420	550	180	1,205	1.4	680	1,565	550	180
V1	1,890	1.6	1,205	2,565	565	190	1,100	1.4	680	1,470	565	190
V2	1,835	1.4	945	2,185	425	140	1,050	1.2	525	1,235	425	140
V3	2,045	1.6	1,155	2,755	550	180	1,205	1.4	680	1,565	550	180

For SI: 1 psi = 6.895 kPa
(a)The characteristic values may be obtained from the published allowable design values for lumber in the U.S. as follows: $f_{b,0}$ =2.1 x published allowable bending stress (F_b), $f_{t,0}$ = 2.1 x published allowable tensile stress (F_t), $f_{c,0}$ = 1.9 x published allowable compressive stress parallel to grain (F_c), $f_{v,0}$ = 3.15 x published allowable shear stress (F_v), and $f_{s,0}$ = 1/3 x calculated $f_{v,0}$.

Table 2.2: Required Characteristic Strengths and Moduli of Elasticity for ANSI/APA PRG 320 Laminations (Source: Yeh et al., 2012)

CLT Grade	CLT Thickness (in)	Lamination Thickness (in.) in CLT Layup							Major Strength Direction			Minor Strength Direction		
		=	⊥	=	⊥	=	⊥	=	$F_bS_{eff,0}$ (lbf-ft/ft)	$EI_{eff,0}$ (10^6 lbf-in^2/ft)	$GA_{eff,0}$ (10^6lbf/ft)	$F_bS_{eff,90}$ (lbf-ft/ft)	$EI_{eff,90}$ (10^6 lbf-in^2/ft)	$GA_{eff,90}$ (10^6lbf/ft)
E1	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.46	160	3.1	0.61
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,400	440	0.92	1,370	81	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	18,375	1,089	1.4	3,125	309	1.8
E2	4 1/8	1 3/8	1 3/8	1 3/8					3,825	102	0.53	165	3.6	0.56
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			8,825	389	1.1	1,430	95	1.1
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	15,600	963	1.6	3,275	360	1.7
E3	4 1/8	1 3/8	1 3/8	1 3/8					2,800	81	0.35	110	2.3	0.44
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			6,400	311	0.69	955	61	0.87
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	11,325	769	1.0	2,180	232	1.3
E4	4 1/8	1 3/8	1 3/8	1 3/8					4,525	115	0.53	180	3.6	0.63
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			10,425	441	1.1	1,570	95	1.3
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	18,400	1,090	1.6	3,575	360	1.9
V1	4 1/8	1 3/8	1 3/8	1 3/8					2,090	108	0.53	165	3.6	0.59
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			4,800	415	1.1	1,430	95	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	8,500	1,027	1.6	3,275	360	1.8
V2	4 1/8	1 3/8	1 3/8	1 3/8					2,030	95	0.46	160	3.1	0.52
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			4,675	363	0.91	1,370	81	1.0
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	8,275	898	1.4	3,125	309	1.6
V3	4 1/8	1 3/8	1 3/8	1 3/8					2,270	108	0.53	180	3.6	0.59
	6 7/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8			5,200	415	1.1	1,570	95	1.2
	9 5/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	1 3/8	9,200	1,027	1.6	3,575	360	1.8

For SI: 1 in. = 25.4 mm; 1 ft. = 304.8 mm; 1 lbf = 4.448 N
(a)This table represents one of many possibilities that the CLT could be manufactured by varying lamination grades, thicknesses, orientations, and layer arrangements in the layup.
(b) Custom CLT grades are not listed in this table are permitted in accordance with ANSI/APA PRG 320.
(c) The allowable properties can be converted to the characteristic properties by multiplying the tabulated F_bS by 2.1, EI and GA by 1.0.

Table 2.3: The Allowable Design Capacities for CLT (Source: Yeh et al., 2012)

2.5 PREVIOUS RESEARCH ON PROPERTIES OF SALVAGED WOOD

Falk et. al (1999) tested the properties of 2 by 10 lumber collected from an US Army Ammunition plant to compare it with those of newly produced lumber. About 500 samples were visually graded and 100 of these were mechanically graded. The standards used for visual grading were exactly duplicated as done for freshly sawn lumber. Some of the defects could not be categorized under the normal established characteristics such as splits, checks, wane etc. These were created during the deconstruction of the old structure, fasteners and also due to years of loading. Most of the salvaged members were floor joists and roof rafters. 3-point bending tests were performed to determine the Modulus of Elasticity (MOE). Since the sample size was small and there was a mixture of three species namely, Douglas Fir-Larch, Southern Pine and Hem-Fir, the Modulus of Rupture (MOR) data could not provide a strong judgement of the samples. The results acquired after testing the samples were compared to an in-grade study data. It was concluded that the MOE values of the visually graded salvaged lumber were comparable to the values of freshly sawn lumber, whereas the bending strength was slightly lower. Since the lumber was obtained from an ammunition plant, the bending strength might have been affected due chemical contamination.

According to another study conducted by Falk (1999), due to the damage, it was observed that the salvaged lumber was one grade lower in quality when contrasted to freshly sawn lumber. Moreover, when bending tests were conducted on these members in accordance with ASTM D198 methods, it was discovered that heart checks reduce the MOR but has no remarkable effect on the bending strength of the reclaimed material.

The effects of splits and checks on shear strength of lumber samples from the military buildings were evaluated using 4-point and 5-point bending tests (Rammer 1999). The samples were divided into two groups based on the volume of splits and checks present along the length of the members. The 4-point and 5-point bending tests were performed to evaluate the shear strength at the ends and middle of the beam respectively. The results of the 5-point bending tests indicated that a lower specific gravity member with comparatively larger size had higher shear strength. It is known that specific gravity is directly proportional to shear strength. It was hence derived that the effect of size had a greater impact than the specific gravity, since Rammer and Lebow (1997) claim that size also influences shear strength. Rammer (1999) also deduced that flexural values of the Douglas-fir members were not affected by splits and checks but lowered the MOR.

Chini (2001) performed 3-point bending tests in which the results indicated that the salvaged lumber when compared to virgin lumber, was 50% denser, had greater allowable MOE and bending stress. In this research, the samples were trimmed to shorter lengths so that the damage created by construction, deconstruction and loading are eliminated. This resulted in increase of grade by 3 levels. It is evident that salvaged wood shows promising characteristics and properties for reuse. Chini also suggests the development of new grading standards specifically for salvaged lumber, after testing their engineering properties, that incorporate various factors such as the effect of damage, duration of loading and exposure. This paper focuses on testing the engineering properties of lumber obtained from a 50-year-old abandoned building, visually and mechanically grade these members using existing grading standards whilst taking into consideration the aforementioned factors that influence the characteristics of the members.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The objectives of this research are achieved in three phases and are as follows:

PHASE 1:

Characterize the physical and mechanical properties of the salvaged wooden members

PHASE 2:

Manufacture CLT panels using the salvaged lumber and test their properties

PHASE 3:

Demonstrate the applicability of using salvaged lumber in CLTs by statistically analyzing the results of the comparison groups

3.2 CHARACTERIZATION OF SALVAGED LUMBER

68 Southern Yellow Pine species wooden members of 2 x 12 dimensions (1.5 in x 11.5 in) were extracted from an abandoned building in Bay City that had been built in the 1950 and deconstructed in the mid 2010s. The average length of these samples were 15 feet. A combination of these salvaged lumber and virgin lumber material will be used to manufacture CLT panels as per the ANSI/APA PRG-320 standards. The salvaged lumber and the manufactured CLT panels' certain characteristics of interest were developed as variables for this study. The variables developed for assessing the salvaged lumber constitute its physical and mechanical properties. Whereas, for the

manufactured CLT panels, the variables include the physical and mechanical properties of the final product as well as the position of salvaged lumber in the CLT layup.

3.2.1 MACHINE GRADING

The samples were evaluated using a Metriguard 340-E Computer. This instrument calculates the dynamic Modulus of Elasticity (MOE) and specific gravity of a wooden board based on its natural frequency prompted by tapping its center. The setup consists of a computer user interface, one tripod containing a calibrated load-cell and another tripod with a knife-edge. It was calibrated everyday using a weight of 11 lbs. and an aluminum calibration bar. The bar is 1 x 2.5 x 96 inches, imitates a 2 x 4 and has an E value of about 2.24×10^6 psi or 15.5Gpa. The weight is mounted on the load-cell to standardize it and verify its accuracy. The samples were placed flatwise on the load cell and the knife-edge with a 1-inch overhang on each side.

The Modulus of Elasticity (MOE) is calculated by the following formula by using the frequency of vibration, span length and the sample weight and dimensions:

$$E = (f_n^2 \, WL^3) / (Kbh^3)$$

Where E is the MOE, f_n is the undamped natural frequency, W is the weight of the test sample, L is the span length, K is the adjustment of constant for incorporating the units used and support conditions, b is the width of the sample and h is the thickness of the sample.

To be more accurate in showing the effect of MOE on the grade value of the CLT panels to be manufactured, the 2 x 12 boards were then cut into 6 pieces of 2 x 4 dimensions each. A coding system was developed and labelled on the pieces to track the origin of each sample. The original 2 x 12 boards were labelled by the numbers 1 through 68. Then, the 15 ft. samples were cut into 2 halves of 7.5 ft. each and were labelled as A and B following the sample number. For instance, sample 4 was cut and labelled as 4A and 4B. The 7.5 ft. boards were further cut into 2 x 4s. Those were labelled as a, b and c following the sample number and A or B. For instance, 4A is cut into three pieces 4Aa, 4Ab and 4Ac and, 4B is cut into three pieces 4Ba, 4Bb and 4Bc. Figure 3.1 helps us better understand the coding system.

The 408 samples of 2 x 4 dimensions were tested on the Metriguard 340-E Computer to calculate the MOE.

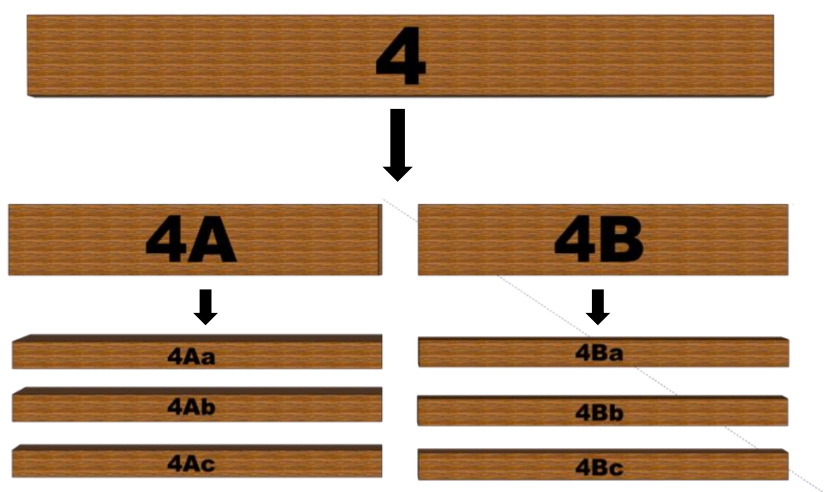

Figure 3.1: Coding System

3.2.2 ANALYSIS OF PROPERTIES

3.2.2.1 MOE VS MOR RELATIONSHIP

30 of the 408 samples were randomly selected using a random sequence generator employing Python programming language. These were subjected to 3-point bending tests on Instron Model 4206. This instrument calculates the elasticity and Modulus of Rupture (MOR) of a specimen. The setup consists of a computer with Blue Hill 2.0 software and a compression machine comprising a load-cell with end supports that are 14 in. apart. The dimensions of the samples to be tested on the Instron were decided to be of 1 x 1 in. dimensions and 16 in. length. To maintain the accuracy of the analysis, samples were taken from the middle and both the ends of the 30 panels. These panels were divided into 3 parts and were labelled right (R), middle (M) and left (L) following the sample numbers and letters. For example, sample 4Aa was divided into 3 parts namely, 4AaR, 4AaM and 4AaL. The 1 x 1 in. samples were extracted from the center of the three portions after planing. The 90 samples were then subjected to 3-point bending tests on the Instron 4206.

The Instron machine was calibrated once every day before placing the samples on the end supports with 1-inch overhang on each side. A testing method template was created, and the speed of the boom was adjusted to 1.3 mm per minute. The load-cell boom height was adjusted using the ‘UP’ and ‘DOWN’ buttons on the Instron machine until the Flexural Load indicated on the user-interface was close to zero. The Gauge Length was reset, and the bending test was then performed with the load-cell exerting force on the middle of the specimen. The MOE and MOR are recorded until the sample reaches failure point. The Maximum Flexure Load (lbf) and Extension at Maximum Load (mm) is also calculated.

3.2.2.2 CORRELATING VISUAL DEFECTS AND MECHANICAL PROPERTIES

27 samples were assessed for visual defects, and these were recorded. The types of defects are as follows:

- Knots – size and placement of the knots on the narrow and edge faces
- Shakes/Checks – cracks formed due to years of loading or caused during deconstruction
- End Splits – cracks in the ends caused due to deconstruction or while material handling and transportation
- Nail holes/Screw Holes– every nail hole was of 4 mm diameter. The number and placement of the holes were noted
- Other damages – some of the samples had significant damage. For instance, a major chunk of wood was chipped off. The amount of fungal damage was also noted as a percentage of the surface area

3.3 PERFORMANCE OF CLT PANELS

3.3.1 MANUFACTURING STANDARDS AND PROCESS

After collecting the physical and mechanical properties data of the salvaged lumber panels, the focus was shifted to manufacturing CLT panels as per the ANSI/APA PRG-320 requirements.

CLT panels are manufactured using dimensional lumber and are bonded using adhesives in their face, end and/or edge joints. The PRG-320 has specific requirements for the individual components of the CLT and must be carefully considered. These are as follows:

3.3.1.1 LAMINATIONS

The standards necessitate the same lumber species or species combinations to be used in the same layer to avoid distinctive physical and mechanical properties. However, it is permissible to use different species or species combination in adjacent layers of the CLT. It also requires a minimum specific gravity of 0.35 since it is the base value for any commercially produced lumber in North America. For freshly sawn lumber, a minimum value of 1200-1.2E MSR or a No.2 visual grade is required in longitudinal layers. Whereas a minimum of No.3 visual grade is required for the transverse layers. To be considered as an equivalent to solid-sawn lumber, remanufactured lumber should qualify in accordance with the Section 5.4 of the ANSI A190.1 standard.

At the time of gluing, to aid face bonding, the net lamination thickness of all the layers must be in the range of 5/8 inch (16mm) to 2 inches (51mm). Moreover, the thickness of laminations shall not vary within the same layer except for the time during face bonding. During the process of face bonding, across the width of a lamination, the thickness variation shall not exceed ±0.008 inch (0.20 mm). The thickness variation shall not exceed ±0.012 inch (0.30 mm) along the length of a lumber.

The net width of laminations in the major strength direction shall be at least 1.75 times the net lamination thickness. In the minor strength direction, for layers that are not edge-bonded, the net lamination width shall be at least 3.5 times the net lamination thickness unless there is an evaluation of interlaminar strength and creep.

3.3.1.2 ADHESIVES

Adhesives are a crucial part of CLT. According to the standards, adhesives should meet the requirements of ANSI 405 except for the glue-bond durability tests mentioned in the Section 2.1.6 of ANSI 405. These tests are used to assess the durability of adhesives used in exterior applications are not applicable since CLT products are maintained in dry service conditions. Following are the most common type of adhesives used in CLT production:

- Phenol-resorcinol formaldehyde (PRF)
- Emulsion polymer isocyanate (EPI) and,
- Polyurethane (PUR)

3.3.1.3 PANEL DIMENSIONS AND DIMENSIONAL TOLERANCES

The overall thickness of a CLT shall not exceed 20 inches (508 mm) according to the ANSI/APA PRG 320. Following are the dimension tolerances permitted at the time of manufacturing:

- CLT Thickness: ±1/16 inch (1.6 mm) or 2% of the CLT thickness, whichever is greater
- CLT Width: ±1/8 inch (3.2 mm)

- CLT Length: ±1/4 inch (6.4 mm)

Alterations in tolerances specified above are permitted for textured or other face or edge finishes. In such case, the designer shall compensate for any losses in strength and/or the cross-section.

The standard also mentions about the squareness of a CLT, which is defined as the length of the two panel face diagonals measured between panel corners, to be lesser than 1/8 inch (3.2 mm). It also specifies that the straightness of a CLT, defined as the deviation of edges from a straight line between adjacent panel corners, shall be within 1/16 inch (1.6 mm).

3.3.1.4 CLT MANUFACTURING PROCESS

A CLT panel consists of three or more layers of dimensional lumber that is of same or different thicknesses which are oriented orthogonally in alternate layers. The manufacturing process consists of the following steps:

- *Primary Lumber Selection* - In this step, the moisture content (MC) of the lumber is assessed and is assured that a MC of 12 ± 3% is maintained to ensure a proper bond quality. The temperature of the wood should be at least 60 degrees Fahrenheit. The collected samples had a moisture content in the range of 10 to 14%. Since the adhesive used in this experiment is moisture-cured, the samples having a MC greater than 12% were selected to manufacture the CLTs

- *Lumber Grouping* - For a E-class CLT, the parallel layers are usually E-rated, and the perpendicular layers are visually graded. For a V-class CLT, all the layers are visually graded. Hence, the major and the minor strength direction lumbers are grouped to test the engineering properties. However, since custom layers are permitted by the ANSI/APA PRG 320, this research involves manufacturing of CLT panels that have E-rated lumber in both parallel and perpendicular layers.
- *Lumber Planing* - Lumber is planed or surfaced to ensure effective gluing by reducing the oxidation of the wood surface. Planing all sides of the lumber will ensure dimensional uniformity.
- *Lumber Cutting to Length* - The wood is cut into specific length for stacking. The dimensions of the 5-layer CLT manufactured in this research is 17.5 inch x 3.5 inch and each layer is about 1.25 inch thick. The minor strength direction lumber is cut into 5 pieces of 3.5 inch each by length to be stacked orthogonal to the major strength direction lumber.
- *Adhesive Application* – Parallel lines of adhesive is applied on a layer and is uniformly wetted to aid curing and effective spread rate. The surface must be devoid of any adhesive-repellant substances such as oils or greases. Adhesive must be applied immediately after planing to avoid surface oxidation or aging and thus improving bonding effectiveness.
- *CLT Panel Lay-up* – This step involves assembly of the layers of the CLT
- *Assembly Pressing* – It is usually done using a vacuum press or a hydraulic press. Assembly time is the duration from adhesive application to the assembly press. The assembly time and the pressing time should be as mentioned by the adhesive manufacturer and a minimum temperature of 60 degrees Fahrenheit must be maintained. Polyurethane (PUR) was used as the adhesive for this experiment. Per the requirements of the adhesive product, about 4

to 5 milligrams of PUR was used per layer and each CLT panel was pressed at 116 psi for 150 minutes. A room temperature of 65 F to 85 F was maintained.

3.3.2 MECHANICAL TESTING OF CLT PANELS

The manufactured 5-layer CLT panels were subjected to 3-point bending tests on the Instron 4206. The panels were placed flatwise with 1 inch overhang on each side. MOE and MOR values of each sample was recorded.

3.3.3 COMPARISON GROUPS

The CLT panels were manufactured as a combination of salvaged lumber and virgin lumber. The mechanical properties of the 3 following groups were compared:

Group 1 (S40%): 30 samples with salvaged lumber used in the minor strength direction and virgin lumber in the major strength direction. Salvaged lumber constituted 40% of the sample.

Group 2 (S60%): 30 samples with salvaged lumber used in the major strength direction and virgin lumber in the minor strength direction. Salvaged lumber constituted 60% of the sample.

Figure 3.2: CLT Lay-ups

Group 3 (Control): 30 control samples were manufactured which consisted of virgin lumber in both transverse and longitudinal layers. The purpose of the control samples is to justify the accuracy of data produced in the mechanical testing of the CLT panels containing a proportion of salvaged lumber. It also helps in understanding the effect of the salvaged lumber on the properties of the CLT panels when compared against the other 2 groups.

CHAPTER 4: RESULTS

This chapter will analyze the results of the various tests performed on the raw materials as well as the final products. First, we will look at the results of the 27 samples that were visually inspected. Secondly, the descriptive statistics of the non-destructive tests performed on the 408 raw salvaged lumber samples. Thirdly, analysis of the bending tests performed on the 90 randomly selected samples. The results will then be compared against the requirements of the CLT standards. Finally, the three CLT sample groups were compared using One-way ANOVA and Tukey Test.

4.1 VISUAL INSPECTION

Defect	No. of Samples w/defects	Instances per Board		
		Min.	Max.	Mean
Nail Holes (1/8") Narrow Face	16	0	6	1.48
Nail Holes (1/8") Wide Face Edge	0	0	0	0
Nail Holes (1/8") Wide Face Center Line	0	4	16	8.85
Bolt Holes (1/8") Narrow Face	0	0	0	0
Bolt Holes (1/8") Wide Face Edge	0	0	0	0
Bolt Holes (1/8") Wide Face Center Line	27	4	4	4
Edge Defect 1/6[a]	2	1	1	0.07
Edge Defect 1/3	0	0	0	0
Edge Defect ½	0	0	0	0
Notes: a/ Defects are inclusive of knots, knot holes, burls, large checks, and distorted grain (slope >1:10), and other damage to include tear outs, rot, insect damage, and fire damage.				

Table 4.1: Visual Inspection Data (Berghorn et. al 2020)

23 of the 27 samples that were visually inspected graded as 2.0E6 SPF based on the MOE data in the Metriguard results. Two of those samples, namely, #44 and #58, could not meet the grade due

to the presence of large knots. This concludes that 21 of the 27 samples were still grading as 2.0E6 SPF, which was about 77.7 percent of the sample population (Berghorn et al 2020).

	MOE (Mpsi)	**SG**
KNOTS	1.761	0.57
HOLES	2.016	0.605
DAMAGE	1.985	0.58
CHECKS	2.415	0.64425
LEAST DAMAGE	2.2675	0.6315

Table 4.2: Visually Inspected Material Data

The average MOE and specific gravity values of the visually inspected 2 x 12 samples were analyzed to evaluate the effects of knots, nail holes, damage, and checks on the properties of the material. From Table 4.2, it can be observed that samples that had the highest number of checks recorded the highest mean MOE value of 2.415 Mpsi. Samples with high number of knots had the lowest MOE value of 1.761 Mpsi. There was no significant difference in the specific gravity values between the samples. However, the average MOE value of the samples that had the least amount of damage was higher than samples that had the highest amount of knots, nail holes, and damage.

4.2 METRIGUARD DATA

The mean Modulus of Elasticity (MOE) of the 408 samples was 2.085 Mpsi. The lowest MOE value was 0.89 Mpsi whereas the highest MOE recorded was 3.76 Mpsi. The median value of the set was 2.1 Mpsi which was close to the mode value. A standard deviation of 0.481 Mpsi and a variance of 0.231 Mpsi was observed in the data. The Inter Quartile Range (IQR) was calculated to be 0.62 Mpsi where the first Quartile Q_1 was 1.77 Mpsi and the third Quartile Q_3 was 2.39 Mpsi. The outliers were samples having MOE values greater than 3.42 Mpsi. The mean Specific Gravity (SG) of the salvaged wood was 0.585. The median value of SG was observed to be 0.581 with Q_1 being 0.535 and Q_3 being 0.627.

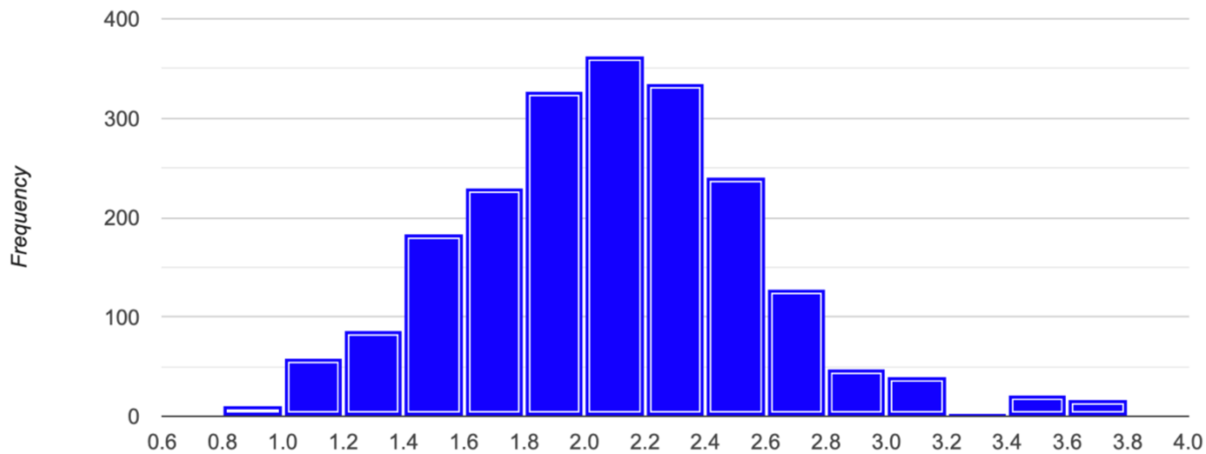

Figure 4.1: Metriguard MOE Histogram

4.3 INSTRON DATA OF RAW SALVAGED LUMBER

The 90 random samples that were subjected to the 3-point bending tests using Instron had a mean MOE value of 1.693 Mpsi. The median value of the set was 1.679 Mpsi. A standard deviation of 0.416 Mpsi and a variance of 0.173 Mpsi was observed in the data. The Inter Quartile Range (IQR) was calculated to be 0.479 Mpsi where the first Quartile Q_1 was 1.478 Mpsi and the third Quartile Q_3 was 1.958 Mpsi. There was one outlier sample which had an MOE of 2.721 Mpsi.

The Modulus of Rupture (MOR) was also recorded by the Instron for the 90 samples. The mean value was 14,558.87 psi and the median value of the set was 14,764.57 psi. It had a standard deviation of 3,856.37 psi. The Inter Quartile Range (IQR) was calculated to be 3,738.58 psi where the first Quartile Q_1 was 12,998.92 psi and the third Quartile Q_3 was 16,726.50 psi. There were 4 outliers that had MOR values of 112.04 psi, 130.56 psi, 7,047.34 psi, 7,255.50 psi and 25,605.51 psi.

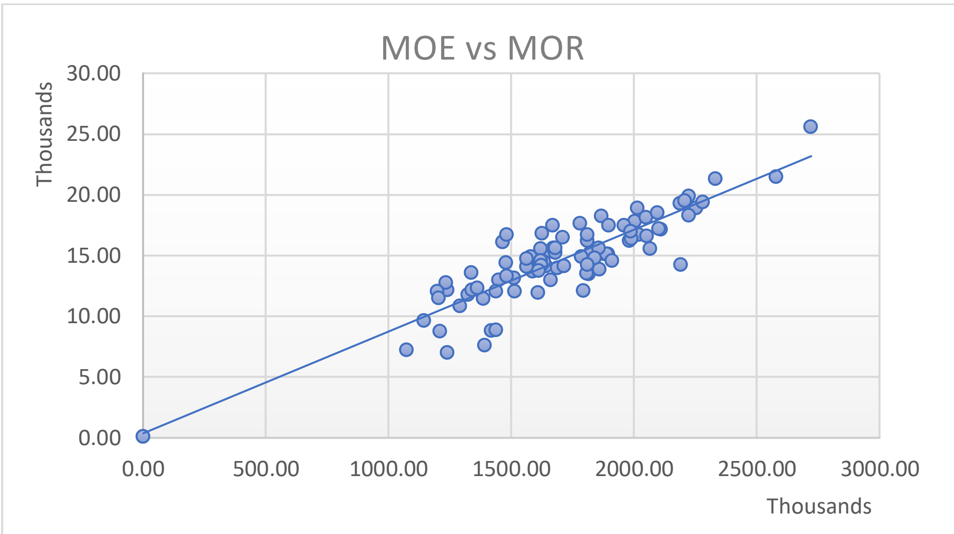

Figure 4.2: Instron MOE vs MOR

Some of the MOE values were recorded as zero when Instron failed to record the value. This was mostly due to the sample failing completely. The tabular Metriguard and Instron test data is in Appendix A. The MOE and MOR were strongly and positively correlated with r = 0.85. The R^2 value was equal to 0.73.

4.4 COMPARISON AGAINST STANDARDS

Section 6 of the ANSI/APA PRG-320 mentions the minimum requirement for the laminations to be qualified as feedstock for the CLT panels. The minimum lumber grade of the longitudinal layers of CLT must be 1200f-1.2E. Based on our Metriguard data, the 408 samples that were of 2 x 12 dimension had a mean MOE value of 2.085 Mpsi which is well above the minimum criteria. Some of the samples had MOE values greater than 3 Mpsi. The MOE values were lower for the samples tested on Instron but had a mean value of 1.693 Mpsi which is still suitable for use according to the requirements. The specific gravity of the lumber used, according to the PRG 320, must have a minimum value of 0.35. The average specific gravity of the lumber samples recorded was 0.585. The lower quartile of the sample had a value of 0.535 which is also well above the requirement.

4.5 CLT PANELS INSTRON TEST DATA

To understand the influence of salvaged wood on the overall properties of the final product, the properties of the feedstock itself was tracked and analyzed. This was achieved by selecting a group, in this case the 60% salvaged wood samples (S60%), where each of the 30 CLT panels were exclusively made from one salvaged wood sample. For instance, sample number 56Bb was used in all the major axis layers for Sample 1 of the S60%. The MOE value of 56Bb was then compared to the overall MOE of the CLT Sample 1. Three CLT samples with the highest and three with the lowest MOE values were chosen. The average MOE value of the salvaged lumber pieces that were present in the CLT samples that had high MOE values was 1.76 Mpsi. Whereas the mean MOE of the raw samples that were components of low MOE CLT samples was 2.02 Mpsi. It was observed that there was no meaningful relation between the MOE of the final product and its components. Moreover, the mean MOE values of the CLT samples were much lower than its components. Though there were 5 layers of 1.25 inches thick panels in each CLT sample compared to the 1 inch thick raw samples, the speed of the machine's boom of 1.3 mm per minute was maintained. This acted as a probable cause for the low MOE values. Another contributing factor may be machine error. To effectively examine the impact of salvaged wood on the properties of the CLT samples, a group comparison was performed.

The comparison between the 3 sample groups was performed using the IBM SPSS software. Tables 4.2, 4.3 and 4.4 illustrate the mechanical properties of the CLT panels recorded by the Instron machine. The descriptive statistics of the data shows that the mean values of the two experimental groups were significantly higher than the control group (Table 4.5). The standard deviation is higher in the group that has the salvaged lumber in the major axis direction.

In the One-Way ANOVA test, the categorical independent variable was the position or percentage of the salvaged lumber in a sample whereas the continuous dependent variable was the Young's Modulus of the sample. The hypothesis for this experiment was that the inclusion of salvaged lumber as a component in CLT panels will impact the MOE value of the material. The significance level or the p-value was assumed to be 0.05. Since the PRG 320 considers the MOE value as the main parameter to classify or grade CLT, this experiment also follows the same.

Specimen Label	Maximum Flexure Load (lbf)	Extension at Maximum Load (mm)	MOR (psi)	MOE (psi)	Salvaged lumber Samples Label
2V-1	11,926.92	29.84	2,117.20	12,159.86	56Bb
2V-2	13,116.49	33.35	2,328.37	12,739.35	33Bc
2V-3	10,657.43	32.16	1,891.85	11,863.70	12Ab
2V-4	11,145.69	32.24	1,978.52	11,863.70	18Ac
2V-5	9,991.61	30.49	1,773.66	12,160.29	68Ba
2V-6	11,052.48	25.51	1,961.98	37,778.31	8Bc
2V-7	10,568.65	36.03	1,876.09	12,428.41	18Ba
2V-8	9,929.49	27.08	1,762.63	-----	25Aa
2V-9	13,928.78	29.26	2,472.56	11,863.59	21Bc
2V-10	13,072.11	42.21	2,320.49	12,160.24	33Ba
2V-11	9,259.24	26.45	1,643.65	14,601.99	27Ba
2V-12	10,728.44	18.88	1,904.46	43,196.08	28Ab
2V-13	11,456.41	24.06	2,033.68	31,414.22	23Ab
2V-14	9,951.67	26.28	1,766.57	4,274.81	20Aa
2V-15	9,689.78	28.88	1,720.08	475.5	18Aa
2V-16	10,586.42	18.56	1,879.25	11,863.49	13Aa
2V-17	8,047.45	19.64	1,428.54	11,619.54	24Bb
2V-18	12,774.71	27.66	2,267.70	10,318.87	14Ac
2V-19	8,460.26	22.31	1,501.82	26,306.64	28Aa
2V-20	9,587.70	17.77	1,701.96	17,397.54	19Aa
2V-21	11,332.11	22.84	2,011.62	31,487.45	18Bb
2V-22	9,982.75	26.44	1,772.09	23,370.29	56Ab
2V-23	9,059.48	24.52	1,608.19	16,985.85	8Ab
2V-24	10,772.84	10.70	1,912.34	59,428.92	13Bc
2V-25	12,859.06	25.37	2,282.67	11,863.49	9Ac
2V-26	11,114.63	17.74	1,973.01	47,779.57	6Bb
2V-27	11,376.51	33.31	2,019.50	36,175.18	5Ac
2V-28	9,392.40	25.70	1,667.29	1,016.03	8Aa
2V-29	12,206.55	22.97	2,166.84	44,780.38	24Ba
2V-30	9,605.45	20.21	1,705.11	33,877.95	21Ab

Table 4.3: Salvaged Lumber in Major Axis (2 Virgin Layers)

Specimen Label	Maximum Flexure Load (lbf)	Extension at Maximum Load (mm)	MOR (psi)	MOE (psi)	Salvaged lumber Sample Label
3V-1	10,608.60	35.44	1,883.18	38,412.03	14Ab
3V-2	7,621.34	23.76	1,352.90	13,049.39	25Ab, 7Bc
3V-3	8,287.15	25.48	1,471.09	14,603.81	16Bb
3V-4	9,343.56	33.35	1,658.62	19,393.75	1Ac, 16Bb
3V-5	8,407.00	27.26	1,492.37	26,599.99	68Bb
3V-6	6,418.43	17.37	1,139.37	32,354.54	1Ac, 4Ac
3V-7	9,374.63	23.60	1,664.14	19,697.46	22Ab, 23Ac
3V-8	9,245.92	37.75	1,641.29	12,844.51	4Ab
3V-9	9,148.26	32.02	1,623.95	25,825.71	24Ac
3V-10	10,164.72	36.95	1,804.39	34,253.08	16Ab
3V-11	7,128.62	32.69	1,265.44	12,169.51	14Ab, 12Bc
3V-12	11,491.93	33.80	2,039.99	10,533.72	23Ac, 12Bc
3V-13	8,353.73	28.70	1,482.91	12,160.29	22Ac
3V-14	9,454.52	25.02	1,678.32	15,012.37	62Ab
3V-15	8,043.01	25.44	1,427.75	632.37	14Ab
3V-16	8,913.00	28.82	1,582.19	21,593.96	14Ab
3V-17	9,543.30	25.49	1,694.08	18,204.85	16Bb, 1Ac
3V-18	6,391.80	25.35	1,134.64	23,891.97	25Bc
3V-19	7,852.14	18.03	1,393.87	33,445.94	14Ab
3V-20	8,256.07	29.01	1,465.57	36,513.03	11Bb, 15Ac
3V-21	8,114.02	33.20	1,440.36	-----	68Bb
3V-22	10,732.90	33.37	1,905.25	12,428.51	18Ab
3V-23	7,528.12	28.49	1,336.35	12,160.13	14Ab, 18Ab
3V-24	8,003.07	29.99	1,420.66	24,984.67	25Ab
3V-25	7,244.04	20.43	1,285.92	21,902.41	1Bb, 66Bb
3V-26	9,348.00	36.88	1,659.41	15,242.18	11Bc
3V-27	6,378.48	19.63	1,132.27	22,744.23	7Bb
3V-28	8,402.54	23.78	1,491.58	21,282.29	7Ba
3V-29	8,402.54	22.69	1,491.58	36,156.37	33Bb, 10Ba
3V-30	8,549.02	28.26	1,517.58	17,761.70	17Bb

Table 4.4: Salvaged Lumber in Minor Axis (3 Virgin Layers)

Specimen Label	Maximum Flexure Load (lbf)	Extension at Maximum Load (mm)	MOR (psi)	MOE (psi)
C-1	7,195.20	36.46	1,277.26	12,739.36
C-2	9,037.30	47.88	1,604.25	8,787.47
C-3	10,777.27	31.88	1,913.13	30,293.88
C-4	9,534.42	23.35	1,692.50	31,274.87
C-5	8,975.15	23.00	1,593.22	28,774.03
C-6	8,753.21	29.26	1,553.82	14,184.58
C-7	8,016.38	25.04	1,423.03	5,233.51
C-8	5,884.00	21.08	1,044.50	6,334.53
C-9	10,999.21	47.52	1,952.52	12,160.29
C-10	7,026.55	28.20	1,247.32	15,875.94
C-11	8,300.47	22.95	1,473.46	-----
C-12	10,000.50	33.65	1,775.24	6,899.90
C-13	6,560.47	28.62	1,164.58	1,928.95
C-14	8,739.89	34.51	1,551.46	12,428.64
C-15	6,538.27	21.83	1,160.64	13,136.15
C-16	7,363.88	33.50	1,307.20	12,428.64
C-17	8,056.33	32.69	1,430.12	2,508.82
C-18	7,852.14	25.23	1,393.87	12,160.29
C-19	8,615.62	38.17	1,529.40	-----
C-20	7,377.20	26.42	1,309.56	4,899.36
C-21	6,946.63	31.55	1,233.13	2,040.98
C-22	10,155.86	32.95	1,802.82	1,255.63
C-23	7,008.78	23.31	1,244.16	8,230.80
C-24	9,126.06	26.31	1,620.01	6,293.45
C-25	7,199.66	28.42	1,278.05	6,455.84
C-26	8,269.38	37.43	1,467.94	3,481.41
C-27	9,166.00	26.84	1,627.10	11,056.31
C-28	7,426.03	34.01	1,318.23	12,429.56
C-29	6,817.93	20.37	1,210.28	10,474.93
C-30	4,705.08	12.85	835.22	16,278.14

Table 4.5: Control Samples (All Virgin Layers)

It was observed that the usage of salvaged lumber had significant impact on the MOE value of the samples, $F(2, 87) = 7.499$, $p = 0.000989308$. Since $p < 0.05$, the difference in means is statistically significant.

Type	Mean	Std. Error	95% Confidence Interval for Mean			
			Lower Bound	Upper Bound	Minimum	Maximum
Salvaged in Major Axis	20441.708	2791.52473	14732.3989	26151.0171	0	59428.92
Salvaged in Minor Axis	20195.159	1804.2399	16505.0741	23885.2439	0	38412.03
Control	10334.8753	1499.79759	7267.4448	13402.3058	0	31274.87
TOTAL	16990.5808	1301.25159	14405.0216	19576.14	0	59428.92

Table 4.6: Descriptive Statistics

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1994340469	2	997170234.7	7.499	<.001
Within Groups	11568637748	87	132972847.7		
TOTAL	13562978217	89			

Table 4.7: One-Way ANOVA Results

Since one-way ANOVA is a test for overall difference between all the groups, it does not exactly support the hypothesis of the experiment. Thus, a post-hoc test was conducted to determine where the difference lies. In this research, the Tukey HSD (honestly significant difference) test was used.

				95% Confidence Interval	
(I) Group	(J) Group	Mean Difference (I-J)	Sig.	Lower Bound	Upper Bound
S60%	S40%	246.549	0.996	-6852.9788	7346.0768
	Control	10106.83267*	**0.003**	3007.3049	17206.3605
S40%	S60%	-246.549	0.996	-7346.0768	6852.9788
	Control	9860.28367*	**0.004**	2760.7559	16959.8115
Control	S60%	-10106.83267*	**0.003**	-17206.3605	-3007.3049
	S40%	-9860.28367*	**0.004**	-16959.8115	-2760.7559
*. The mean difference is significant at the 0.05 level					

Table 4.8: Post-Hoc (Tukey HSD) Test Results

The results showed that there is a significant difference in the means when each of the experimental group was compared against the control sample. The p-values for the samples with salvaged lumber in major axis and minor axis were 0.003 and 0.004 respectively. There was no significant difference between the two experimental groups. This shows that the percentage of salvaged components in the CLT panels did not have a significant effect on the MOE values. Overall, the sample groups containing salvaged lumber in minor and major axes seem to exhibit better mechanical properties based on the destructive test results.

CHAPTER 5: SUMMARY

5.1 OVERVIEW

The primary outcome of this study was to evaluate the impact of using salvaged lumber as one of the feedstock materials in wood products such as CLT panels.

The variables or factors that need to be considered while evaluating the properties of the sample material were derived from the literature review performed initially. It allowed us to explore the body of knowledge and understand concepts behind previous research experiments that had similar goals. The results of those past experiments also equipped us with the understanding of our current stance in evaluating the feasibility of reusing salvaged wood material.

The characteristics of interest were namely, the species of wood, duration of loading, type of loading the member had been subjected to, physical damage, number of knots and checks, mechanical properties such as MOE, MOR, specific gravity, and moisture content, and finally, the original grade of the samples. All the 68 samples were of Southern Yellow Pine species. Since the building was built in the late 50s, it was concluded that the samples were under load for at least 60 years. The type of loading could not be determined, but since the samples were 2 x 12 long span members, it was assumed that these were decks. The destructive and non-destructive tests recorded the mechanical properties of the samples. The original grade of the material could not be determined since there were not grade stamps present except for a few samples. Moisture content of the samples were in the range of 9 to 15 percent. The samples chosen to use in the manufacturing of CLT panels had a moisture content of at least 12 percent.

Since only 68 samples were collected from a single deconstruction project, the samples were further cut into smaller pieces to increase the sample size. Each piece was numbered per the developed coding system. The mechanical properties of the raw samples were recorded by performing tests on Metriguard and Instron. The results were analyzed to evaluate the impact of the determined variables on the overall performance of the salvaged lumber. The samples satisfied the requirement criteria for usage in CLT panels.

CLT panels were manufactured in three groups, two experimental and one control. The experimental groups were manufactured using a mixture of virgin lumber and varying proportions of salvaged lumber. Since these were hand-manufactured unlike the traditional machine manufacturing method, the number of samples were decided to be as high as 30 to alleviate the effect of human error. All the samples were then subjected to 3-point bending tests on Instron.

One-way ANOVA and Tukey tests were performed to analyze the impact of the salvaged lumber on the overall mechanical properties. The experimental group performed much better than the control group. It was concluded that the inclusion of salvaged lumber in wood products is not only a viable option but also a better one.

5.2 FUTURE RESEARCH

The unknown variables in this experiment which had an impact on the overall properties of the material may be of interest to future researchers. Knowing the type of load that the samples were subjected to, longitudinal or transverse, would have helped in analyzing the effect of the direction of load.

The virgin lumber used in this experiment had a grade value of 2100f whereas the salvaged lumber's grades were unfamiliar. Few samples that had grade stamps on them showed a value of 1600f. When the CLT sample groups were compared, the influence of grade on the MOE values could not be established. Since we know that few salvaged lumber pieces which were graded 1600f performed better and had higher MOE values than the pure virgin CLT samples of grade 2100f, it gives us a glimpse of the salvaged material's endurance.

Since there was no significant difference in the mean MOE values between the groups having 3 layers and 2 layers of salvaged lumber, it could be possible that the salvaged lumber in the 2 layers were of higher grades when compared to the 3 layers. Making S60% and S40% CLT panels using salvaged lumber pieces extracted from a single sample could have tested this hypothesis. Due to the limited availability, samples could not be grouped as mentioned to determine this information.

The coding system developed in this experiment could help in tracking the properties of the samples that were used in the CLT panels and compare it with the properties of the parent board.

The CLT samples were subjected to bending tests only in the major strength direction. Performing the same tests by applying force in the minor strength direction and analyzing the results will provide a holistic idea of how the same material will perform.

The adhesive used in this research is called Polyurethane (PUR). The waste generated in cutting wood can be used to extract lignin. This can be used as a substitute to PUR as a bio-based adhesive to bond layers of the CLT.

Moreover, the process of planing wood generates a considerable amount of powdered wood waste. It can be assessed if CLT panels can be made of laminations that are not planed. Evaluating the feasibility of not planing wood and still maintain the same mechanical properties would start a new and interesting discussion.

5.3 CONCLUSION

By exploring the option of streaming in salvaged lumber into commercial wood products, this research has pioneered in treading an uncharted territory. For many years, researchers have tried to record the properties of used lumber and claimed the normalization of its re-usage. This experiment provides data that attests to this claim and enlightens not only environmentalists but also economists. With the current unpredictable situation of lumber prices, the ability to reuse wood will be a blessing to the industry. This project has lived through one of the most grave pandemics in history where the economy rolled the dice every day. As we move towards a new world where climate change plays a crucial role in major decisions, the ability to have a reliable and continuous source of reusable lumber would be welcomed and celebrated. With limited resources and various obstacles, this experiment has succeeded with results that support its claim. It is in the best interest of people involved in this research that future enthusiasts will try to travel deeper into this uncharted territory and will further strengthen the claims put forth.

APPENDICES

APPENDIX A: METRIGUARD DATA

Description:	Sample 1Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.18	3	0.548	10	8	15.99
2	2.16	3	0.548	10	8	15.93
3	2.17	3	0.548	10	8	15.94
4	2.16	3	0.541	9.8	8	16.02
5	2.15	3	0.539	9.8	8	16.02
6	2.15	3	0.539	9.8	8	16.02

Description:	Sample 1Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.13	3	0.535	9.7	8	15.99
2	2.14	3	0.534	9.7	8	16.03
3	2.14	3	0.534	9.7	8	16.03
4	2.17	3	0.542	9.8	8	16.04
5	2.18	3	0.542	9.8	8	16.07
6	2.18	3	0.542	9.8	8	16.07

Description:	Sample 1Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.77	4	0.511	9.3	8	14.92
2	1.77	4	0.51	9.3	8	14.93
3	1.78	4	0.511	9.3	8	14.94
4	1.87	4	0.532	9.7	8	15.02
5	1.86	4	0.53	9.6	8	15.03
6	1.87	4	0.53	9.6	8	15.04

Table A.1: Metriguard Readings

Table A.1 (cont'd.)

Description:	Sample 1Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.16	3	0.573	10.4	8	15.58
2	2.16	3	0.573	10.4	8	15.55
3	2.16	3	0.573	10.4	8	15.57
4	2.09	4	0.558	10.1	8	15.5
5	2.09	4	0.558	10.1	8	15.5
6	2.08	4	0.56	10.2	8	15.46

Description:	Sample 1Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.2	3	0.6	10.9	8	15.35
2	2.19	3	0.601	10.9	8	15.31
3	2.21	3	0.601	10.9	8	15.36
4	2.07	4	0.56	10.2	8	15.44
5	2.07	4	0.558	10.1	8	15.44
6	2.07	4	0.558	10.1	8	15.42

Description:	Sample 1Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.2	3	0.557	10.1	8	15.94
2	2.21	3	0.558	10.1	8	15.97
3	2.21	3	0.557	10.1	8	15.98
4	2.13	3	0.533	9.7	8	16.03
5	2.14	3	0.534	9.7	8	16.04
6	2.13	3	0.533	9.7	8	16.04

Description:	Sample 2Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.62	1	0.679	12.3	8	15.72
2	2.61	1	0.679	12.3	8	15.7
3	2.62	1	0.678	12.3	8	15.75
4	2.68	1	0.697	12.7	8	15.69
5	2.67	1	0.697	12.7	8	15.67
6	2.67	1	0.697	12.7	8	15.66

Table A.1 (cont'd.)

Description:	Sample 2Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.71	1	0.707	12.8	8	15.67
2	2.7	1	0.707	12.8	8	15.65
3	2.69	1	0.707	12.8	8	15.62
4	2.7	1	0.693	12.6	8	15.79
5	2.67	1	0.691	12.6	8	15.74
6	2.69	1	0.691	12.6	8	15.79

Description:	Sample 2Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.96	1	0.7	12.7	8	16.45
2	2.96	1	0.702	12.8	8	16.44
3	2.97	1	0.702	12.8	8	16.46
4	2.98	1	0.697	12.7	8	16.57
5	2.99	1	0.695	12.6	8	16.59
6	2.99	1	0.697	12.7	8	16.58

Description:	Sample 2Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.41	2	0.69	12.5	8	14.95
2	2.43	2	0.691	12.6	8	14.99
3	2.42	2	0.691	12.6	8	14.97
4	2.45	2	0.694	12.6	8	15.03
5	2.45	2	0.694	12.6	8	15.03
6	2.46	2	0.695	12.6	8	15.04

Description:	Sample 2Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.41	2	0.747	13.6	8	14.37
2	2.41	2	0.746	13.6	8	14.39
3	2.4	2	0.746	13.6	8	14.36
4	2.27	3	0.707	12.8	8	14.35
5	2.28	3	0.707	12.8	8	14.38
6	2.29	3	0.707	12.8	8	14.39

Table A.1 (cont'd.)

Description:	Sample 2Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.88	1	0.811	14.7	8	15.08
2	2.89	1	0.812	14.8	8	15.09
3	2.89	1	0.812	14.8	8	15.1
4	2.69	1	0.761	13.8	8	15.05
5	2.68	1	0.759	13.8	8	15.05
6	2.7	1	0.761	13.8	8	15.06

Description:	Sample 3Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.18	3	0.613	11.1	8	15.1
2	2.2	3	0.614	11.2	8	15.16
3	2.2	3	0.614	11.2	8	15.16
4	2.25	3	0.626	11.4	8	15.19
5	2.25	3	0.624	11.3	8	15.19
6	2.23	3	0.624	11.3	8	15.13

Description:	Sample 3Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.639	11.6	8	15.34
2	2.34	3	0.639	11.6	8	15.32
3	2.35	3	0.641	11.6	8	15.33
4	2.36	3	0.638	11.6	8	15.37
5	2.38	3	0.639	11.6	8	15.44
6	2.38	3	0.641	11.6	8	15.42

Description:	Sample 3Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.51	2	0.628	11.4	8	16
2	2.51	2	0.628	11.4	8	16.01
3	2.51	2	0.628	11.4	8	16.01
4	2.41	2	0.603	11	8	16.02
5	2.4	2	0.601	10.9	8	15.99
6	2.39	3	0.601	10.9	8	15.97

Table A.1 (cont'd.)

Description:	Sample 3Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.45	4	0.629	11.4	8	12.13
2	1.44	4	0.629	11.4	8	12.13
3	1.44	4	0.629	11.4	8	12.12
4	1.44	4	0.627	11.4	8	12.12
5	1.44	4	0.627	11.4	8	12.12
6	1.44	4	0.627	11.4	8	12.13

Description:	Sample 3Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.58	2	0.627	11.4	8	16.23
2	2.6	2	0.628	11.4	8	16.27
3	2.58	2	0.628	11.4	8	16.22
4	2.66	1	0.642	11.7	8	16.28
5	2.65	1	0.639	11.6	8	16.29
6	2.65	1	0.641	11.6	8	16.28

Description:	Sample 4Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.81	4	0.48	8.7	8	15.53
2	1.81	4	0.48	8.7	8	15.56
3	1.82	4	0.48	8.7	8	15.61
4	1.92	4	0.504	9.2	8	15.64
5	1.92	4	0.504	9.2	8	15.64
6	1.92	4	0.502	9.1	8	15.63

Description:	Sample 4Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.87	4	0.511	9.3	8	15.29
2	1.87	4	0.51	9.3	8	15.31
3	1.87	4	0.51	9.3	8	15.33
4	1.82	4	0.495	9	8	15.36
5	1.81	4	0.495	9	8	15.32
6	1.82	4	0.495	9	8	15.35

Table A.1 (cont'd.)

Description:	Sample 4Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.65	4	0.495	9	8	14.63
2	1.64	4	0.494	9	8	14.59
3	1.65	4	0.495	9	8	14.64
4	1.64	4	0.487	8.9	8	14.67
5	1.63	4	0.487	8.9	8	14.65
6	1.64	4	0.487	8.9	8	14.67

Description:	Sample 4Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.22	3	0.527	9.6	8	16.44
2	2.21	3	0.528	9.6	8	16.39
3	2.22	3	0.528	9.6	8	16.42
4	2.24	3	0.535	9.7	8	16.38
5	2.26	3	0.535	9.7	8	16.44
6	2.25	3	0.534	9.7	8	16.41

Description:	Sample 4Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.51	9.3	8	15.9
2	2.01	4	0.51	9.3	8	15.9
3	2.01	4	0.51	9.3	8	15.9
4	2.05	4	0.52	9.5	8	15.89
5	2.06	4	0.52	9.5	8	15.91
6	2.04	4	0.52	9.5	8	15.85

Description:	Sample 4Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.06	4	0.533	9.7	8	15.75
2	2.06	4	0.533	9.7	8	15.73
3	2.06	4	0.533	9.7	8	15.75
4	2.13	3	0.549	10	8	15.74
5	2.14	3	0.551	10	8	15.76
6	2.13	3	0.551	10	8	15.76

Table A.1 (cont'd.)

Description:	Sample 5Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.19	3	0.559	10.1	8	15.83
2	2.19	3	0.559	10.1	8	15.85
3	2.19	3	0.559	10.1	8	15.85
4	2.13	3	0.548	9.9	8	15.77
5	2.13	3	0.546	9.9	8	15.79
6	2.13	3	0.546	9.9	8	15.8

Description:	Sample 5Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.29	3	0.565	10.3	8	16.1
2	2.29	3	0.565	10.3	8	16.11
3	2.29	3	0.565	10.3	8	16.09
4	2.32	3	0.575	10.4	8	16.08
5	2.32	3	0.574	10.4	8	16.09
6	2.32	3	0.574	10.4	8	16.09

Description:	Sample 5Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.33	3	0.546	9.9	8	16.53
2	2.33	3	0.545	9.9	8	16.55
3	2.34	3	0.545	9.9	8	16.57
4	2.32	3	0.545	9.9	8	16.5
5	2.32	3	0.546	9.9	8	16.51
6	2.33	3	0.546	9.9	8	16.51

Description:	Sample 5Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.28	3	0.572	10.4	8	15.98
2	2.29	3	0.573	10.4	8	16
3	2.29	3	0.573	10.4	8	16.01
4	2.3	3	0.574	10.4	8	16.01
5	2.3	3	0.574	10.4	8	16.03
6	2.3	3	0.573	10.4	8	16.02

Table A.1 (cont'd.)

Description:	Sample 5Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.34	3	0.613	11.1	8	15.64
2	2.34	3	0.615	11.2	8	15.61
3	2.35	3	0.615	11.2	8	15.65
4	2.37	3	0.69	12.5	8	14.83
5	2.36	3	0.616	11.2	8	15.66
6	2.36	3	0.616	11.2	8	15.66

Description:	Sample 5Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.93	4	0.61	11.1	8	14.24
2	1.93	4	0.61	11.1	8	14.24
3	1.94	4	0.611	11.1	8	14.24
4	1.91	4	0.608	11	8	14.19
5	1.94	4	0.611	11.1	8	14.24
6	1.93	4	0.61	11.1	8	14.25

Description:	Sample 6Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.97	4	0.589	10.7	8	14.6
2	1.97	4	0.59	10.7	8	14.59
3	1.98	4	0.59	10.7	8	14.64
4	2.06	4	0.609	11.1	8	14.67
5	2.06	4	0.608	11	8	14.7
6	2.05	4	0.608	11	8	14.68

Description:	Sample 6Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.77	4	0.625	11.4	8	13.44
2	1.77	4	0.624	11.3	8	13.43
3	1.77	4	0.625	11.4	8	13.44
4	1.87	4	0.662	12	8	13.41
5	1.87	4	0.663	12.1	8	13.42
6	1.87	4	0.663	12.1	8	13.39

Table A.1 (cont'd.)

Description:	Sample 6Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.96	4	0.579	10.5	8	14.68
2	1.97	4	0.581	10.6	8	14.69
3	1.96	4	0.58	10.5	8	14.69
4	1.96	4	0.58	10.5	8	14.69
5	1.97	4	0.582	10.6	8	14.7
6	1.96	4	0.581	10.6	8	14.65

Description:	Sample 6Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.546	9.8	7.9	15.77
2	2.02	4	0.545	9.8	7.9	15.83
3	2.02	4	0.545	9.8	7.9	15.83
4	2.01	4	0.545	9.8	7.9	15.81
5	2.02	4	0.545	9.8	7.9	15.83
6	2.02	4	0.545	9.8	7.9	15.83

Description:	Sample 6Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.75	4	0.593	10.8	8	13.68
2	1.75	4	0.593	10.8	8	13.68
3	1.75	4	0.593	10.8	8	13.69
4	1.78	4	0.601	10.9	8	13.71
5	1.78	4	0.6	10.9	8	13.74
6	1.79	4	0.601	10.9	8	13.76

Description:	Sample 6Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.55	10	8	15.66
2	2.13	3	0.551	10	8	15.67
3	2.13	3	0.55	10	8	15.67
4	2.16	3	0.562	10.2	8	15.64
5	2.17	3	0.563	10.2	8	15.64
6	2.17	3	0.563	10.2	8	15.66

Table A.1 (cont'd.)

Description:	Sample 7Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.58	4	0.556	10.1	8	13.58
2	1.57	4	0.556	10.1	8	13.55
3	1.57	4	0.556	10.1	8	13.55
4	1.47	4	0.516	9.3	8	13.57
5	1.48	4	0.517	9.4	8	13.61
6	1.47	4	0.517	9.4	8	13.59

Description:	Sample 7Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.45	4	0.531	9.6	8	13.23
2	1.44	4	0.53	9.6	8	13.21
3	1.46	4	0.531	9.6	8	13.25
4	1.45	4	0.532	9.7	8	13.2
5	1.45	4	0.531	9.6	8	13.2
6	1.46	4	0.531	9.6	8	13.25

Description:	Sample 7Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.65	4	0.531	9.6	8	14.1
2	1.65	4	0.531	9.6	8	14.1
3	1.65	4	0.531	9.6	8	14.12
4	1.63	4	0.521	9.5	8	14.14
5	1.63	4	0.521	9.5	8	14.14
6	1.62	4	0.521	9.5	8	14.13

Description:	Sample 7Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.19	4	0.492	8.9	8	12.42
2	1.19	4	0.492	8.9	8	12.46
3	1.19	4	0.492	8.9	8	12.45
4	1.15	4	0.478	8.7	8	12.39
5	1.15	4	0.477	8.7	8	12.42
6	1.15	4	0.477	8.7	8	12.43

Table A.1 (cont'd.)

Description:	Sample 7Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.29	4	0.565	10.3	8	12.01
2	1.28	4	0.565	10.3	8	12.01
3	1.29	4	0.565	10.3	8	12.02
4	1.26	4	0.551	10	8	12.05
5	1.27	4	0.553	10.1	8	12.06
6	1.26	4	0.551	10	8	12.05

Description:	Sample 7Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.73	4	0.546	9.9	8	14.19
2	1.74	4	0.548	10	8	14.2
3	1.74	4	0.546	9.9	8	14.2
4	1.58	4	0.502	9.1	8	14.14
5	1.58	4	0.501	9.1	8	14.13
6	1.57	4	0.501	9.1	8	14.1

Description:	Sample 8Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.8	4	0.538	9.8	8	14.66
2	1.8	4	0.538	9.8	8	14.64
3	1.81	4	0.538	9.8	8	14.67
4	1.78	4	0.528	9.6	8	14.69
5	1.77	4	0.528	9.6	8	14.67
6	1.8	4	0.53	9.6	8	14.74

Description:	Sample 8Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.553	10	8	15.45
2	2.04	4	0.552	10	8	15.47
3	2.04	4	0.552	10	8	15.48
4	2.03	4	0.551	10	8	15.46
5	2.03	4	0.551	10	8	15.46
6	2.04	4	0.552	10	8	15.47

Table A.1 (cont'd.)

Description:	Sample 8Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.27	3	0.563	10.2	8	16.16
2	2.28	3	0.563	10.2	8	16.19
3	2.27	3	0.563	10.2	8	16.17
4	2.27	3	0.565	10.2	8	16.14
5	2.27	3	0.563	10.2	8	16.16
6	2.26	3	0.563	10.2	8	16.14

Description:	Sample 8Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.5	2	0.576	10.3	7.9	17.22
2	2.52	2	0.576	10.3	7.9	17.3
3	2.52	2	0.574	10.3	7.9	17.31
4	2.38	3	0.551	9.8	7.9	17.16
5	2.4	2	0.552	9.9	7.9	17.24
6	2.39	3	0.552	9.9	7.9	17.19

Description:	Sample 8Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.4	3	0.569	10.2	7.9	16.96
2	2.42	2	0.57	10.2	7.9	17.01
3	2.4	3	0.57	10.2	7.9	16.94
4	2.33	3	0.56	10	7.9	16.84
5	2.33	3	0.56	10	7.9	16.86
6	2.31	3	0.559	10	7.9	16.79

Description:	Sample 8Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.56	10	7.9	15.78
2	2.04	4	0.56	10	7.9	15.78
3	2.04	4	0.56	10	7.9	15.78
4	2.09	4	0.55	9.8	7.9	16.12
5	2.1	3	0.549	9.8	7.9	16.18
6	2.11	3	0.549	9.8	7.9	16.2

Table A.1 (cont'd.)

Description:	Sample 9Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.64	1	0.64	11.6	8	16.18
2	2.68	1	0.643	11.7	8	16.26
3	2.67	1	0.641	11.7	8	16.25
4	2.69	1	0.648	11.8	8	16.23
5	2.69	1	0.648	11.8	8	16.25
6	2.69	1	0.648	11.8	8	16.25

Description:	Sample 9Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.48	2	0.666	12.1	8	15.46
2	2.48	2	0.666	12.1	8	15.45
3	2.47	2	0.666	12.1	8	15.42
4	2.36	3	0.631	11.5	8	15.47
5	2.37	3	0.632	11.5	8	15.5
6	2.37	3	0.632	11.5	8	15.5

Description:	Sample 9Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.75	1	0.655	11.9	8	16.4
2	2.72	1	0.653	11.9	8	16.33
3	2.74	1	0.655	11.9	8	16.39
4	2.75	1	0.653	11.9	8	16.43
5	2.74	1	0.652	11.9	8	16.41
6	2.75	1	0.652	11.9	8	16.43

Description:	Sample 9Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.81	1	0.6	10.9	8	17.25
2	2.81	1	0.598	10.9	8	17.26
3	2.79	1	0.6	10.9	8	17.19
4	2.84	1	0.612	11.1	8	17.17
5	2.85	1	0.612	11.1	8	17.19
6	2.85	1	0.612	11.1	8	17.2

Table A.1 (cont'd.)

Description:	Sample 9Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.62	1	0.587	10.7	8	16.85
2	2.62	1	0.587	10.7	8	16.84
3	2.6	1	0.586	10.7	8	16.79
4	2.67	1	0.607	11	8	16.72
5	2.68	1	0.607	11	8	16.75
6	2.68	1	0.607	11	8	16.75

Description:	Sample 9Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.74	1	0.616	11.2	8	16.81
2	2.75	1	0.616	11.2	8	16.83
3	2.76	1	0.619	11.3	8	16.82
4	2.82	1	0.631	11.5	8	16.83
5	2.8	1	0.629	11.4	8	16.83
6	2.81	1	0.63	11.5	8	16.84

Description:	Sample 10Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.88	4	0.516	9.4	8	15.28
2	1.88	4	0.516	9.4	8	15.28
3	1.87	4	0.516	9.4	8	15.25
4	1.89	4	0.522	9.5	8	15.24
5	1.91	4	0.522	9.5	8	15.3
6	1.91	4	0.521	9.5	8	15.31

Description:	Sample 10Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.73	4	0.52	9.4	8	14.6
2	1.73	4	0.521	9.5	8	14.57
3	1.73	4	0.521	9.5	8	14.6
4	1.73	4	0.521	9.5	8	14.6
5	1.73	4	0.521	9.5	8	14.57
6	1.72	4	0.52	9.4	8	14.57

Table A.1 (cont'd.)

Description:	Sample 10Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.532	9.7	8	14.79
2	1.82	4	0.532	9.7	8	14.78
3	1.8	4	0.531	9.6	8	14.74
4	1.81	4	0.531	9.6	8	14.79
5	1.82	4	0.532	9.7	8	14.81
6	1.82	4	0.532	9.7	8	14.81

Description:	Sample 10Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.88	4	0.511	9.1	7.9	15.83
2	1.88	4	0.511	9.1	7.9	15.83
3	1.89	4	0.512	9.2	7.9	15.86
4	1.86	4	0.51	9.1	7.9	15.77
5	1.87	4	0.511	9.1	7.9	15.79
6	1.87	4	0.511	9.1	7.9	15.8

Description:	Sample 10Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.79	4	0.52	9.3	7.9	15.31
2	1.8	4	0.52	9.3	7.9	15.36
3	1.8	4	0.52	9.3	7.9	15.38
4	1.75	4	0.568	10.1	7.9	14.5
5	1.79	4	0.52	9.3	7.9	15.32
6	1.8	4	0.52	9.3	7.9	15.35

Description:	Sample 10Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.71	4	0.538	9.6	7.9	14.77
2	1.71	4	0.538	9.6	7.9	14.76
3	1.71	4	0.539	9.6	7.9	14.74
4	1.79	4	0.541	9.7	7.9	15.05
5	1.8	4	0.543	9.7	7.9	15.08
6	1.81	4	0.543	9.7	7.9	15.11

Table A.1 (cont'd.)

Description:	Sample 11Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.22	4	0.539	9.8	8	12.06
2	1.22	4	0.537	9.8	8	12.06
3	1.22	4	0.537	9.8	8	12.07
4	1.22	4	0.539	9.8	8	12.05
5	1.22	4	0.537	9.8	8	12.06
6	1.22	4	0.537	9.8	8	12.07

Description:	Sample 11Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.42	4	0.541	9.8	8	12.94
2	1.42	4	0.541	9.8	8	12.95
3	1.42	4	0.542	9.8	8	12.93
4	1.41	4	0.541	9.8	8	12.93
5	1.42	4	0.542	9.8	8	12.94
6	1.41	4	0.541	9.8	8	12.91

Description:	Sample 11Ba					
Units:	English	E [Mpsi]	Distance [in, ft]			
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.44	4	0.53	9.6	8	13.21
2	1.44	4	0.53	9.6	8	13.2
3	1.44	4	0.532	9.7	8	13.22
4	1.45	4	0.533	9.7	8	13.21
5	1.45	4	0.533	9.7	8	13.23
6	1.45	4	0.533	9.7	8	13.23

Description:	Sample 11Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.19	4	0.511	9.3	8	12.24
2	1.19	4	0.513	9.3	8	12.24
3	1.2	4	0.511	9.3	8	12.27
4	1.18	4	0.501	9.1	8	12.3
5	1.18	4	0.5	9.1	8	12.31
6	1.17	4	0.5	9.1	8	12.29

Table A.1 (cont'd.)

Description:	Sample 11Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.66	4	0.523	9.5	8	14.29
2	1.65	4	0.521	9.5	8	14.28
3	1.66	4	0.523	9.5	8	14.3
4	1.71	4	0.529	9.6	8	14.39
5	1.71	4	0.529	9.6	8	14.4
6	1.71	4	0.529	9.6	8	14.41

Description:	Sample 12Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.23	3	0.548	10	8	16.18
2	2.22	3	0.549	10	8	16.13
3	2.22	3	0.548	10	8	16.15
4	2.11	3	0.515	9.4	8	16.24
5	2.11	3	0.518	9.4	8	16.19
6	2.11	3	0.515	9.4	8	16.24

Description:	Sample 12Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.58	2	0.579	10.5	8	16.92
2	2.6	2	0.579	10.5	8	16.99
3	2.58	2	0.579	10.5	8	16.94
4	2.52	2	0.571	10.4	8	16.86
5	2.51	2	0.571	10.4	8	16.81
6	2.53	2	0.572	10.4	8	16.86

Description:	Sample 12Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.25	3	0.56	10.2	8	16.08
2	2.25	3	0.558	10.1	8	16.11
3	2.25	3	0.558	10.1	8	16.11
4	2.25	3	0.552	10	8	16.19
5	2.24	3	0.551	10	8	16.16
6	2.25	3	0.552	10	8	16.21

Table A.1 (cont'd.)

Description:	Sample 12Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.64	4	0.53	9.6	8	14.1
2	1.65	4	0.532	9.7	8	14.12
3	1.64	4	0.53	9.6	8	14.12
4	1.58	4	0.513	9.3	8	14.08
5	1.59	4	0.514	9.3	8	14.12
6	1.59	4	0.514	9.3	8	14.12

Description:	Sample 12Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.49	4	0.534	9.7	8	13.4
2	1.5	4	0.534	9.7	8	13.44
3	1.5	4	0.534	9.7	8	13.46
4	1.52	4	0.537	9.8	8	13.5
5	1.53	4	0.538	9.8	8	13.51
6	1.52	4	0.538	9.8	8	13.48

Description:	Sample 12Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.43	4	0.483	8.8	8	13.77
2	1.42	4	0.483	8.8	8	13.75
3	1.43	4	0.485	8.8	8	13.8
4	1.45	4	0.485	8.8	8	13.87
5	1.44	4	0.485	8.8	8	13.84
6	1.45	4	0.483	8.8	8	13.88

Description:	Sample 13Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.639	11.6	8	15.83
2	2.48	2	0.639	11.6	8	15.79
3	2.5	2	0.641	11.6	8	15.85
4	2.39	3	0.614	11.2	8	15.81
5	2.38	3	0.614	11.2	8	15.77
6	2.38	3	0.613	11.1	8	15.82

Table A.1 (cont'd.)

Description:	Sample 13Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.11	3	0.593	10.8	8	15.13
2	2.13	3	0.595	10.8	8	15.18
3	2.12	3	0.595	10.8	8	15.14
4	2.11	3	0.59	10.7	8	15.15
5	2.12	3	0.591	10.7	8	15.2
6	2.12	3	0.591	10.7	8	15.18

Description:	Sample 13Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.19	3	0.593	10.8	8	15.42
2	2.21	3	0.593	10.8	8	15.47
3	2.2	3	0.591	10.7	8	15.47
4	2.12	3	0.57	10.4	8	15.46
5	2.11	3	0.57	10.4	8	15.44
6	2.13	3	0.57	10.4	8	15.49

Description:	Sample 13Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.11	3	0.593	10.8	8	15.13
2	2.13	3	0.595	10.8	8	15.18
3	2.12	3	0.595	10.8	8	15.14
4	2.11	3	0.59	10.7	8	15.15
5	2.12	3	0.591	10.7	8	15.2
6	2.12	3	0.591	10.7	8	15.18

Description:	Sample 13Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.19	3	0.593	10.8	8	15.42
2	2.21	3	0.593	10.8	8	15.47
3	2.2	3	0.591	10.7	8	15.47
4	2.12	3	0.57	10.4	8	15.46
5	2.11	3	0.57	10.4	8	15.44
6	2.13	3	0.57	10.4	8	15.49

Table A.1 (cont'd.)

Description:	Sample 13Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.7	1	0.647	11.8	8	16.39
2	2.69	1	0.646	11.7	8	16.38
3	2.71	1	0.646	11.7	8	16.42
4	2.83	1	0.679	12.3	8	16.37
5	2.82	1	0.679	12.3	8	16.35
6	2.81	1	0.678	12.3	8	16.32

Description:	Sample 13Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.615	11.2	8	13.79
2	1.82	4	0.614	11.2	8	13.8
3	1.8	4	0.614	11.2	8	13.74
4	1.83	4	0.659	12	8	13.35
5	1.94	4	0.66	12	8	13.74
6	1.93	4	0.657	11.9	8	13.75

Description:	Sample 13Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.24	3	0.684	12.4	8	14.51
2	2.24	3	0.684	12.4	8	14.53
3	2.24	3	0.683	12.4	8	14.52
4	2.2	3	0.676	12.3	8	14.47
5	2.21	3	0.676	12.3	8	14.48
6	2.19	3	0.675	12.3	8	14.45

Description:	Sample 14Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.18	1	0.726	13.2	8	16.76
2	3.18	1	0.726	13.2	8	16.76
3	3.2	1	0.727	13.2	8	16.78
4	3.13	1	0.713	13	8	16.78
5	3.13	1	0.713	13	8	16.77
6	3.14	1	0.712	12.9	8	16.8

Table A.1 (cont'd.)

Description:	Sample 14Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.7	1	0.695	12.6	8	15.78
2	2.71	1	0.697	12.7	8	15.78
3	2.71	1	0.697	12.7	8	15.77
4	2.79	1	0.716	13	8	15.8
5	2.78	1	0.716	13	8	15.78
6	2.79	1	0.714	13	8	15.82

Description:	Sample 14Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.643	11.7	8	15.73
2	2.48	2	0.643	11.7	8	15.72
3	2.49	2	0.642	11.7	8	15.75
4	2.52	2	0.659	12	8	15.66
5	2.53	2	0.657	11.9	8	15.7
6	2.52	2	0.657	11.9	8	15.66

Description:	Sample 14Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.72	1	0.622	11.3	8	16.74
2	2.74	1	0.623	11.3	8	16.79
3	2.74	1	0.623	11.3	8	16.8
4	2.74	1	0.624	11.3	8	16.76
5	2.74	1	0.624	11.3	8	16.76
6	2.76	1	0.627	11.4	8	16.8

Description:	Sample 14Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.03	1	0.67	12.2	8	17.03
2	3.03	1	0.669	12.2	8	17.05
3	3.02	1	0.669	12.2	8	17.02
4	3.06	1	0.676	12.3	8	17.01
5	3.06	1	0.678	12.3	8	17.01
6	3.06	1	0.676	12.3	8	17.02

Table A.1 (cont'd.)

Description:	Sample 14Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.96	1	0.652	11.9	8	17.04
2	2.97	1	0.653	11.9	8	17.05
3	2.95	1	0.653	11.9	8	17.01
4	3.04	1	0.679	12.3	8	16.93
5	3.06	1	0.679	12.3	8	16.99
6	3.06	1	0.679	12.3	8	16.99

Description:	Sample 15Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.75	1	0.611	11.1	8	16.98
2	2.73	1	0.611	11.1	8	16.92
3	2.73	1	0.611	11.1	8	16.93
4	2.75	1	0.611	11.1	8	16.97
5	2.75	1	0.611	11.1	8	16.99
6	2.75	1	0.61	11.1	8	16.99

Description:	Sample 15Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.61	1	0.63	11.4	8	16.28
2	2.61	1	0.63	11.4	8	16.3
3	2.59	2	0.63	11.4	8	16.24
4	2.6	1	0.629	11.4	8	16.28
5	2.61	1	0.63	11.4	8	16.3
6	2.62	1	0.63	11.4	8	16.31

Description:	Sample 15Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.15	1	0.669	12.2	8	17.36
2	3.16	1	0.67	12.2	8	17.36
3	3.15	1	0.67	12.2	8	17.34
4	3.19	1	0.75	13.6	8	16.5
5	3.15	1	0.669	12.2	8	17.36
6	3.16	1	0.67	12.2	8	17.36

Table A.1 (cont'd.)

Description:	Sample 15Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.78	1	0.603	11	8	17.19
2	2.8	1	0.601	10.9	8	17.28
3	2.83	1	0.601	10.9	8	17.37
4	2.66	1	0.575	10.4	8	17.22
5	2.64	1	0.573	10.4	8	17.18
6	2.65	1	0.573	10.4	8	17.22

Description:	Sample 15Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.47	2	0.567	10.3	8	16.71
2	2.47	2	0.567	10.3	8	16.71
3	2.45	2	0.567	10.3	8	16.64
4	2.38	3	0.551	10	8	16.63
5	2.38	3	0.551	10	8	16.64
6	2.38	3	0.549	10	8	16.66

Description:	Sample 15Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.577	10.5	8	14.95
2	2	4	0.576	10.5	8	14.93
3	2.01	4	0.576	10.5	8	14.94
4	1.99	4	0.57	10.4	8	14.94
5	1.98	4	0.568	10.3	8	14.95
6	1.98	4	0.568	10.3	8	14.94

Description:	Sample 16Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.518	9.4	8	15.76
2	2.01	4	0.518	9.4	8	15.76
3	2.02	4	0.518	9.4	8	15.82
4	1.92	4	0.504	9.2	8	15.61
5	1.92	4	0.504	9.2	8	15.62
6	1.92	4	0.504	9.2	8	15.61

Table A.1 (cont'd.)

Description:	Sample 16Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.93	4	0.529	9.6	8	15.29
2	1.94	4	0.53	9.6	8	15.29
3	1.94	4	0.53	9.6	8	15.3
4	1.91	4	0.518	9.4	8	15.37
5	1.91	4	0.518	9.4	8	15.37
6	1.9	4	0.518	9.4	8	15.33

Description:	Sample 16Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.558	10.1	8	15.61
2	2.12	3	0.558	10.1	8	15.64
3	2.12	3	0.558	10.1	8	15.62
4	2.08	4	0.549	10	8	15.6
5	2.08	4	0.549	10	8	15.59
6	2.09	4	0.549	10	8	15.62

Description:	Sample 16Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.15	3	0.557	10.1	8	15.75
2	2.16	3	0.558	10.1	8	15.78
3	2.15	3	0.558	10.1	8	15.72
4	2.08	4	0.537	9.8	8	15.77
5	2.07	4	0.537	9.8	8	15.74
6	2.08	4	0.538	9.8	8	15.77

Description:	Sample 17Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.22	4	0.506	9.2	8	12.47
2	1.23	4	0.506	9.2	8	12.48
3	1.22	4	0.506	9.2	8	12.47
4	1.24	4	0.514	9.3	8	12.48
5	1.24	4	0.513	9.3	8	12.48
6	1.24	4	0.513	9.3	8	12.49

Table A.1 (cont'd.)

Description:	Sample 17Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.2	4	0.542	9.8	8	11.94
2	1.2	4	0.539	9.8	8	11.95
3	1.2	4	0.541	9.8	8	11.96
4	1.22	4	0.548	10	8	11.94
5	1.21	4	0.547	9.9	8	11.94
6	1.21	4	0.547	9.9	8	11.94

Description:	Sample 17Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.25	4	0.505	9.2	8	12.64
2	1.25	4	0.505	9.2	8	12.64
3	1.24	4	0.504	9.2	8	12.6
4	1.29	4	0.52	9.5	8	12.65
5	1.29	4	0.519	9.4	8	12.66
6	1.29	4	0.519	9.4	8	12.66

Description:	Sample 17Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.481	8.7	8	15.59
2	1.82	4	0.481	8.7	8	15.61
3	1.82	4	0.481	8.7	8	15.59
4	1.87	4	0.496	9	8	15.56
5	1.87	4	0.496	9	8	15.55
6	1.86	4	0.496	9	8	15.55

Description:	Sample 17Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.72	4	0.514	9.3	8	14.66
2	1.72	4	0.514	9.3	8	14.66
3	1.71	4	0.514	9.3	8	14.64
4	1.79	4	0.519	9.4	8	14.88
5	1.78	4	0.519	9.4	8	14.85
6	1.79	4	0.519	9.4	8	14.87

Table A.1 (cont'd.)

Description:	Sample 17Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.97	4	0.513	9.3	8	15.74
2	1.98	4	0.513	9.3	8	15.74
3	1.97	4	0.513	9.3	8	15.72
4	1.97	4	0.519	9.4	8	15.61
5	1.97	4	0.519	9.4	8	15.63
6	1.97	4	0.519	9.4	8	15.64

Description:	Sample 18Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.27	3	0.575	10.4	8	15.95
2	2.29	3	0.575	10.4	8	16.01
3	2.29	3	0.575	10.4	8	16
4	2.37	3	0.579	10.5	8	16.21
5	2.36	3	0.579	10.5	8	16.21
6	2.35	3	0.579	10.5	8	16.16

Description:	Sample 18Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.36	3	0.595	10.8	8	15.98
2	2.36	3	0.594	10.8	8	15.98
3	2.36	3	0.595	10.8	8	15.98
4	2.39	3	0.603	11	8	15.97
5	2.4	3	0.604	11	8	15.97
6	2.4	3	0.604	11	8	15.97

Description:	Sample 18Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.43	2	0.59	10.7	8	16.26
2	2.44	2	0.593	10.8	8	16.28
3	2.41	2	0.591	10.7	8	16.2
4	2.44	2	0.591	10.7	8	16.27
5	2.44	2	0.591	10.7	8	16.27
6	2.43	2	0.59	10.7	8	16.26

Table A.1 (cont'd.)

Description:	Sample 18Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.96	4	0.598	10.9	8	14.52
2	1.95	4	0.598	10.9	8	14.5
3	1.95	4	0.596	10.8	8	14.51
4	2	4	0.596	10.8	8	14.67
5	2	4	0.596	10.8	8	14.67
6	1.99	4	0.596	10.8	8	14.64

Description:	Sample 18Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.83	4	0.595	10.8	8	14.07
2	1.83	4	0.594	10.8	8	14.07
3	1.84	4	0.595	10.8	8	14.1
4	1.84	4	0.595	10.8	8	14.12
5	1.84	4	0.595	10.8	8	14.11
6	1.85	4	0.594	10.8	8	14.15

Description:	Sample 18Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.94	4	0.591	10.7	8	14.54
2	1.95	4	0.591	10.7	8	14.54
3	1.94	4	0.591	10.7	8	14.51
4	2.74	1	0.609	11.1	8	17.01
5	1.96	4	0.586	10.7	8	14.68
6	1.95	4	0.586	10.7	8	14.63
7	1.97	4	0.585	10.6	8	14.71

Description:	Sample 19Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.21	3	0.562	10.2	8	15.85
2	2.2	3	0.562	10.2	8	15.84
3	2.21	3	0.563	10.2	8	15.86
4	2.31	3	0.59	10.7	8	15.84
5	2.29	3	0.589	10.7	8	15.8
6	2.32	3	0.59	10.7	8	15.87

Table A.1 (cont'd.)

Description:	Sample 19Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.39	3	0.601	10.9	8	15.96
2	2.4	2	0.603	11	8	15.98
3	2.4	3	0.601	10.9	8	15.97
4	2.53	2	0.636	11.6	8	15.97
5	2.51	2	0.636	11.6	8	15.91
6	2.53	2	0.634	11.5	8	15.98

Description:	Sample 19Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.39	3	0.568	10.3	8	16.42
2	2.39	3	0.568	10.3	8	16.42
3	2.39	3	0.568	10.3	8	16.41
4	2.44	2	0.585	10.6	8	16.34
5	2.46	2	0.585	10.6	8	16.41
6	2.46	2	0.585	10.6	8	16.42

Description:	Sample 19Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.5	2	0.535	9.7	8	17.29
2	2.49	2	0.534	9.7	8	17.29
3	2.5	2	0.534	9.7	8	17.3
4	2.5	2	0.535	9.7	8	17.3
5	2.5	2	0.535	9.7	8	17.3
6	2.5	2	0.535	9.7	8	17.3

Description:	Sample 19Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.561	10.2	8	16.69
2	2.44	2	0.561	10.2	8	16.7
3	2.46	2	0.562	10.2	8	16.76
4	2.48	2	0.562	10.2	8	16.82
5	2.49	2	0.563	10.2	8	16.82
6	2.48	2	0.562	10.2	8	16.82

Table A.1 (cont'd.)

Description:	Sample 19Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.06	4	0.532	9.7	8	15.76
2	2.06	4	0.529	9.6	8	15.79
3	2.07	4	0.53	9.6	8	15.8
4	2.07	4	0.538	9.8	8	15.71
5	2.1	4	0.541	9.8	8	15.77
6	2.1	3	0.541	9.8	8	15.79

Description:	Sample 20Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.93	4	0.599	10.9	8	14.38
2	1.93	4	0.598	10.9	8	14.38
3	1.93	4	0.598	10.9	8	14.39
4	1.94	4	0.596	10.8	8	14.43
5	1.95	4	0.596	10.8	8	14.46
6	1.94	4	0.595	10.8	8	14.47

Description:	Sample 20Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.74	4	0.601	10.9	8	13.75
2	1.74	4	0.601	10.9	8	13.75
3	1.74	4	0.599	10.8	8	13.76
4	1.68	4	0.635	11.5	8	13.11
5	1.74	4	0.599	10.8	8	13.75
6	1.74	4	0.599	10.8	8	13.75

Description:	Sample 20Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.76	4	0.601	10.9	8	13.83
2	1.76	4	0.601	10.9	8	13.83
3	1.77	4	0.602	10.9	8	13.85
4	1.7	4	0.606	11	8	13.52
5	1.7	4	0.607	11	8	13.52
6	1.71	4	0.608	11	8	13.52

Table A.1 (cont'd.)

Description:	Sample 20Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.58	2	0.608	11.1	8	16.42
2	2.58	2	0.607	11	8	16.41
3	2.58	2	0.607	11	8	16.43
4	2.51	2	0.613	11.2	8	16.11
5	2.51	2	0.613	11.2	8	16.12
6	2.49	2	0.613	11.2	8	16.05

Description:	Sample 20Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.601	10.9	8	16.04
2	2.43	2	0.601	10.9	8	16.01
3	2.44	2	0.601	10.9	8	16.05
4	2.38	3	0.601	10.9	8	15.87
5	2.39	3	0.601	10.9	8	15.88
6	2.37	3	0.601	10.9	8	15.82

Description:	Sample 20Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.43	2	0.596	10.7	7.9	16.6
2	2.44	2	0.595	10.7	7.9	16.65
3	2.42	2	0.594	10.6	7.9	16.61
4	2.43	2	0.595	10.7	7.9	16.64
5	2.42	2	0.594	10.6	7.9	16.6
6	2.43	2	0.594	10.6	7.9	16.65

Description:	Sample 21Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.11	3	0.631	11.5	8	14.65
2	2.11	3	0.631	11.5	8	14.63
3	2.12	3	0.632	11.5	8	14.67
4	1.98	4	0.593	10.8	8	14.63
5	2	4	0.595	10.8	8	14.66
6	2	4	0.595	10.8	8	14.67

Table A.1 (cont'd.)

Description:	Sample 21Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.61	4	0.618	11.2	8	12.93
2	1.61	4	0.618	11.2	8	12.93
3	1.61	4	0.618	11.2	8	12.92
4	1.51	4	0.579	10.5	8	12.95
5	1.51	4	0.579	10.5	8	12.94
6	1.5	4	0.577	10.5	8	12.92

Description:	Sample 21Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.43	2	0.637	11.6	8	15.43
2	2.43	2	0.637	11.6	8	15.44
3	2.44	2	0.639	11.7	8	15.43
4	2.38	3	0.629	11.5	8	15.37
5	2.37	3	0.629	11.5	8	15.35
6	2.38	3	0.629	11.5	8	15.38

Description:	Sample 21Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.54	4	0.648	11.8	8	12.34
2	1.53	4	0.645	11.7	8	12.34
3	1.53	4	0.646	11.7	8	12.33
4	1.53	4	0.645	11.7	8	12.33
5	1.54	4	0.645	11.7	8	12.35
6	1.54	4	0.645	11.7	8	12.37

Description:	Sample 21Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.71	4	0.61	11.1	8	13.38
2	1.71	4	0.611	11.1	8	13.38
3	1.71	4	0.611	11.1	8	13.39
4	1.71	4	0.646	11.7	8	13
5	1.77	4	0.645	11.7	8	13.27
6	1.77	4	0.646	11.7	8	13.26

Table A.1 (cont'd.)

Description:	Sample 21Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.675	12.3	8	15.03
2	2.44	2	0.675	12.3	8	15.03
3	2.45	2	0.675	12.3	8	15.05
4	2.47	2	0.68	12.4	8	15.05
5	2.46	2	0.68	12.4	8	15.04
6	2.46	2	0.68	12.4	8	15.04

Description:	Sample 22Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.521	9.5	8	16.97
2	2.35	3	0.521	9.5	8	16.98
3	2.34	3	0.521	9.5	8	16.96
4	2.36	3	0.524	9.5	8	16.99
5	2.36	3	0.525	9.5	8	16.97
6	2.35	3	0.525	9.5	8	16.94

Description:	Sample 22Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.29	3	0.567	10.3	8	16.11
2	2.3	3	0.566	10.3	8	16.16
3	2.29	3	0.566	10.3	8	16.14
4	2.28	3	0.563	10.2	8	16.14
5	2.27	3	0.562	10.2	8	16.11
6	2.27	3	0.562	10.2	8	16.11

Description:	Sample 22Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.66	4	0.521	9.5	8	14.3
2	1.67	4	0.52	9.5	8	14.34
3	1.67	4	0.521	9.5	8	14.33
4	1.71	4	0.535	9.7	8	14.3
5	1.71	4	0.534	9.7	8	14.3
6	1.71	4	0.535	9.7	8	14.31

Table A.1 (cont'd.)

Description:	Sample 22Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.2	3	0.594	10.8	8	15.41
2	2.2	3	0.593	10.8	8	15.42
3	2.2	3	0.593	10.8	8	15.42
4	2.13	3	0.576	10.5	8	15.4
5	2.13	3	0.577	10.5	8	15.39
6	2.14	3	0.577	10.5	8	15.41

Description:	Sample 22Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.83	4	0.613	11.1	8	13.81
2	1.83	4	0.613	11.1	8	13.82
3	1.83	4	0.613	11.1	8	13.83
4	1.82	4	0.605	11	8	13.86
5	1.81	4	0.606	11	8	13.84
6	1.82	4	0.605	11	8	13.86

Description:	Sample 22Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.54	4	0.553	10.1	8	13.35
2	1.54	4	0.553	10.1	8	13.35
3	1.54	4	0.554	10.1	8	13.35
4	1.59	4	0.573	10.4	8	13.35
5	1.59	4	0.572	10.4	8	13.36
6	1.6	4	0.572	10.4	8	13.36

Description:	Sample 23Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.4	2	0.594	10.8	8	16.09
2	2.4	2	0.594	10.8	8	16.1
3	2.41	2	0.595	10.8	8	16.09
4	2.41	2	0.598	10.9	8	16.08
5	2.41	2	0.596	10.8	8	16.07
6	2.42	2	0.598	10.9	8	16.1

Table A.1 (cont'd.)

Description:	Sample 23Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.648	11.8	8	15.23
2	2.34	3	0.646	11.7	8	15.23
3	2.36	3	0.647	11.8	8	15.3
4	2.34	3	0.646	11.7	8	15.25
5	2.35	3	0.647	11.8	8	15.24
6	2.34	3	0.647	11.8	8	15.21

Description:	Sample 23Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.16	3	0.646	11.7	8	14.65
2	2.16	3	0.645	11.7	8	14.64
3	2.16	3	0.646	11.7	8	14.65
4	2.13	3	0.634	11.5	8	14.68
5	2.14	3	0.633	11.5	8	14.72
6	2.14	3	0.633	11.5	8	14.72

Description:	Sample 23Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.52	2	0.646	11.7	8	15.79
2	2.74	1	0.645	11.7	8	16.49
3	2.64	1	0.645	11.7	8	16.19
4	2.81	1	0.674	12.2	8	16.33
5	2.8	1	0.674	12.2	8	16.33
6	2.8	1	0.672	12.2	8	16.34

Description:	Sample 23Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.15	3	0.673	12.2	8	14.23
2	2.13	3	0.672	12.2	8	14.18
3	2.16	3	0.673	12.2	8	14.27
4	2.2	3	0.672	12.2	8	14.44
5	2.14	3	0.678	12.3	8	14.17
6	2.14	3	0.677	12.3	8	14.17

Table A.1 (cont'd.)

Description:	Sample 23Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.56	4	0.653	11.9	8	12.37
2	1.56	4	0.652	11.9	8	12.39
3	1.56	4	0.652	11.9	8	12.38
4	1.52	4	0.636	11.6	8	12.36
5	1.52	4	0.634	11.5	8	12.4
6	1.53	4	0.634	11.5	8	12.41

Description:	Sample 24Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.596	10.8	8	16.36
2	2.48	2	0.598	10.9	8	16.3
3	2.49	2	0.596	10.8	8	16.35
4	2.47	2	0.591	10.7	8	16.36
5	2.48	2	0.593	10.8	8	16.37
6	2.46	2	0.591	10.7	8	16.32

Description:	Sample 24Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.3	3	0.605	11	8	15.61
2	2.3	3	0.605	11	8	15.59
3	2.3	3	0.606	11	8	15.58
4	2.26	3	0.6	10.9	8	15.52
5	2.26	3	0.598	10.9	8	15.57
6	2.25	3	0.599	10.9	8	15.53

Description:	Sample 24Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.77	4	0.628	11.4	8	13.44
2	1.76	4	0.627	11.4	8	13.4
3	1.77	4	0.628	11.4	8	13.43
4	1.78	4	0.628	11.4	8	13.46
5	1.77	4	0.629	11.4	8	13.43
6	1.77	4	0.629	11.4	8	13.41

Table A.1 (cont'd.)

Description:	Sample 24Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.4	3	0.62	11.3	8	15.76
2	2.4	3	0.62	11.3	8	15.76
3	2.39	3	0.62	11.3	8	15.73
4	2.34	3	0.612	11.1	8	15.69
5	2.35	3	0.612	11.1	8	15.7
6	2.34	3	0.612	11.1	8	15.69

Description:	Sample 24Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.24	3	0.601	10.9	8	15.49
2	2.25	3	0.603	11	8	15.49
3	2.26	3	0.604	11	8	15.5
4	2.12	3	0.577	10.5	8	15.36
5	2.12	3	0.577	10.5	8	15.37
6	2.12	3	0.579	10.5	8	15.37

Description:	Sample 24Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.33	3	0.618	11.2	8	15.56
2	2.33	3	0.618	11.2	8	15.58
3	2.33	3	0.618	11.2	8	15.57
4	2.26	3	0.609	11.1	8	15.45
5	2.27	3	0.609	11.1	8	15.49
6	2.28	3	0.61	11.1	8	15.5

Description:	Sample 25Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.87	4	0.513	9.3	8	15.31
2	1.9	4	0.513	9.3	8	15.43
3	1.85	4	0.513	9.3	8	15.23
4	1.85	4	0.502	9.1	8	15.37
5	1.85	4	0.502	9.1	8	15.39
6	1.85	4	0.501	9.1	8	15.39

Table A.1 (cont'd.)

Description:	Sample 25Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.1	3	0.506	9.2	8	16.35
2	2.11	3	0.508	9.2	8	16.36
3	2.11	3	0.508	9.2	8	16.35
4	2.13	3	0.513	9.3	8	16.35
5	2.14	3	0.513	9.3	8	16.38
6	2.14	3	0.513	9.3	8	16.37

Description:	Sample 25Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.77	4	0.561	10.2	8	14.23
2	1.78	4	0.561	10.2	8	14.28
3	1.78	4	0.561	10.2	8	14.29
4	1.67	4	0.541	9.8	8	14.09
5	1.69	4	0.542	9.8	8	14.18
6	1.69	4	0.542	9.8	8	14.17

Description:	Sample 25Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.17	4	0.614	11.2	8	11.06
2	1.17	4	0.615	11.2	8	11.06
3	1.17	4	0.615	11.2	8	11.07
4	1.04	4	0.546	9.9	8	11.06
5	1.03	4	0.546	9.9	8	11.04
6	1.04	4	0.546	9.9	8	11.06

Description:	Sample 25Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.547	9.9	8	15.38
2	2.01	4	0.547	9.9	8	15.38
3	2	4	0.547	9.9	8	15.32
4	1.99	4	0.546	9.9	8	15.3
5	2	4	0.546	9.9	8	15.35
6	1.99	4	0.544	9.9	8	15.32

Table A.1 (cont'd.)

Description:	Sample 26Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.3	4	0.562	10.2	8	12.17
2	1.29	4	0.561	10.2	8	12.18
3	1.3	4	0.561	10.2	8	12.19
4	1.24	4	0.537	9.8	8	12.17
5	1.24	4	0.537	9.8	8	12.18
6	1.23	4	0.535	9.7	8	12.16

Description:	Sample 26Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	0.9	8	0.537	9.8	8	10.41
2	0.9	8	0.535	9.7	8	10.4
3	0.9	8	0.537	9.8	8	10.4
4	0.86	8	0.513	9.3	8	10.4
5	0.86	8	0.511	9.3	8	10.41
6	0.86	8	0.51	9.3	8	10.41

Description:	Sample 26Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.3	4	0.562	10.2	8	12.17
2	1.29	4	0.561	10.2	8	12.18
3	1.3	4	0.561	10.2	8	12.19
4	1.24	4	0.537	9.8	8	12.17
5	1.24	4	0.537	9.8	8	12.18
6	1.23	4	0.535	9.7	8	12.16

Description:	Sample 26Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.33	4	0.468	8.5	8	13.52
2	1.33	4	0.468	8.5	8	13.52
3	1.34	4	0.469	8.5	8	13.54
4	1.31	4	0.458	8.3	8	13.57
5	1.31	4	0.458	8.3	8	13.55
6	1.31	4	0.458	8.3	8	13.54

Table A.1 (cont'd.)

Description:	Sample 26Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.16	4	0.448	8.1	8	12.89
2	1.15	4	0.447	8.1	8	12.89
3	1.16	4	0.448	8.1	8	12.89
4	1.2	4	0.461	8.4	8	12.95
5	1.2	4	0.459	8.3	8	12.95
6	1.2	4	0.461	8.4	8	12.93

Description:	Sample 26Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.18	4	0.425	7.7	8	13.34
2	1.19	4	0.425	7.7	8	13.4
3	1.18	4	0.425	7.7	8	13.35
4	1.21	4	0.431	7.8	8	13.41
5	1.21	4	0.431	7.8	8	13.41
6	1.21	4	0.431	7.8	8	13.4

Description:	Sample 27Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.12	4	0.547	9.9	8	11.46
2	1.12	4	0.547	9.9	8	11.46
3	1.12	4	0.546	9.9	8	11.47
4	1.11	4	0.546	9.9	8	11.46
5	1.12	4	0.547	9.9	8	11.45
6	1.12	4	0.547	9.9	8	11.46

Description:	Sample 27Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.01	4	0.554	10.1	8	10.84
2	1.01	4	0.554	10.1	8	10.84
3	1.01	4	0.554	10.1	8	10.82
4	0.97	8	0.539	9.8	8	10.76
5	0.97	8	0.538	9.8	8	10.79
6	0.97	8	0.538	9.8	8	10.79

Table A.1 (cont'd.)

Description:	Sample 27Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.2	4	0.537	9.7	8	12.01
2	1.19	4	0.534	9.7	8	11.99
3	1.2	4	0.535	9.7	8	12.01
4	1.19	4	0.533	9.7	8	12
5	1.19	4	0.533	9.7	8	11.97
6	1.19	4	0.534	9.7	8	11.96

Description:	Sample 27Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.505	9	7.9	16.86
2	2.11	3	0.505	9	7.9	16.8
3	2.12	3	0.505	9	7.9	16.87
4	2.17	3	0.587	10.5	7.9	15.83
5	2.11	3	0.506	9.1	7.9	16.81
6	2.12	3	0.505	9	7.9	16.87

Description:	Sample 27Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.67	4	0.51	9.1	7.9	14.88
2	1.67	4	0.51	9.1	7.9	14.89
3	1.68	4	0.51	9.1	7.9	14.91
4	1.65	4	0.511	9.2	7.9	14.76
5	1.65	4	0.511	9.2	7.9	14.76
6	1.66	4	0.511	9.2	7.9	14.8

Description:	Sample 27Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.95	4	0.514	9.2	7.9	16.03
2	1.95	4	0.514	9.2	7.9	16.03
3	1.95	4	0.514	9.2	7.9	16.02
4	2.04	4	0.541	9.7	7.9	15.99
5	2.04	4	0.541	9.7	7.9	16
6	2.05	4	0.541	9.7	7.9	16.01

Table A.1 (cont'd.)

Description:	Sample 28Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.61	4	0.485	8.8	8	14.61
2	1.61	4	0.485	8.8	8	14.62
3	1.61	4	0.485	8.8	8	14.61
4	1.59	4	0.478	8.7	8	14.61
5	1.59	4	0.478	8.7	8	14.62
6	1.59	4	0.478	8.7	8	14.63

Description:	Sample 28Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.46	4	0.636	11.6	8	12.14
2	1.46	4	0.636	11.6	8	12.14
3	1.45	4	0.636	11.6	8	12.11
4	1.44	4	0.631	11.5	8	12.13
5	1.44	4	0.632	11.5	8	12.12
6	1.44	4	0.631	11.5	8	12.12

Description:	Sample 28Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.91	4	0.511	9.3	8	15.5
2	1.92	4	0.511	9.3	8	15.52
3	1.91	4	0.511	9.3	8	15.51
4	2	4	0.529	9.6	8	15.59
5	2	4	0.528	9.6	8	15.62
6	2	4	0.528	9.6	8	15.61

Description:	Sample 28Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.51	4	0.519	9.4	8	13.66
2	1.51	4	0.518	9.4	8	13.7
3	1.51	4	0.518	9.4	8	13.68
4	1.5	4	0.515	9.4	8	13.7
5	1.51	4	0.515	9.4	8	13.72
6	1.51	4	0.514	9.3	8	13.74

Table A.1 (cont'd.)

Description:	Sample 28Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2	4	0.567	10.3	8	15.05
2	1.98	4	0.566	10.3	8	15.02
3	2	4	0.567	10.3	8	15.04
4	1.94	4	0.543	9.9	8	15.16
5	1.94	4	0.543	9.9	8	15.15
6	1.95	4	0.544	9.9	8	15.16

Description:	Sample 28Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.41	4	0.48	8.7	8	13.77
2	1.41	4	0.48	8.7	8	13.74
3	1.41	4	0.48	8.7	8	13.72
4	1.44	4	0.485	8.8	8	13.81
5	1.44	4	0.483	8.8	8	13.82
6	1.44	4	0.485	8.8	8	13.8

Description:	Sample 29Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.63	4	0.627	11.2	7.9	13.25
2	1.63	4	0.627	11.2	7.9	13.26
3	1.61	4	0.627	11.2	7.9	13.19
4	1.62	4	0.626	11.2	7.9	13.25
5	1.63	4	0.627	11.2	7.9	13.25
6	1.63	4	0.627	11.2	7.9	13.25

Description:	Sample 29Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.47	4	0.577	10.5	8	12.74
2	1.44	4	0.577	10.5	8	12.61
3	1.44	4	0.577	10.5	8	12.59
4	1.46	4	0.581	10.6	8	12.65
5	1.46	4	0.581	10.6	8	12.62
6	1.46	4	0.579	10.5	8	12.65

Table A.1 (cont'd.)

Description:	Sample 29Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.02	4	0.587	10.7	8	14.78
2	2.02	4	0.588	10.7	8	14.78
3	2.01	4	0.588	10.7	8	14.73
4	2.07	4	0.597	10.9	8	14.84
5	2.06	4	0.596	10.8	8	14.83
6	2.07	4	0.596	10.8	8	14.85

Description:	Sample 29Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.16	3	0.567	10.1	7.9	16.06
2	2.18	3	0.565	10.1	7.9	16.14
3	2.17	3	0.564	10.1	7.9	16.15
4	2.16	3	0.576	10.3	7.9	15.94
5	2.16	3	0.576	10.3	7.9	15.95
6	2.16	3	0.574	10.3	7.9	15.96

Description:	Sample 29Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.76	4	0.553	10.1	8	14.24
2	1.77	4	0.555	10.1	8	14.24
3	1.77	4	0.554	10.1	8	14.25
4	1.77	4	0.555	10.1	8	14.24
5	1.76	4	0.553	10.1	8	14.24
6	1.77	4	0.555	10.1	8	14.25

Description:	Sample 29Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.07	4	0.56	10.2	8	15.33
2	2.07	4	0.559	10.2	8	15.34
3	2.06	4	0.56	10.2	8	15.29
4	2.1	4	0.57	10.4	8	15.28
5	2.12	3	0.57	10.4	8	15.35
6	2.08	4	0.57	10.4	8	15.22

Table A.1 (cont'd.)

Description:	Sample 30Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.524	9.5	8	15.86
2	2.04	4	0.524	9.5	8	15.86
3	2.04	4	0.524	9.5	8	15.86
4	2.04	4	0.524	9.5	8	15.86
5	2.04	4	0.524	9.5	8	15.86
6	2.04	4	0.524	9.5	8	15.86

Description:	Sample 30Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.8	4	0.48	8.7	8	15.57
2	1.8	4	0.48	8.7	8	15.57
3	1.8	4	0.48	8.7	8	15.57
4	1.8	4	0.48	8.7	8	15.57
5	1.8	4	0.48	8.7	8	15.57
6	1.8	4	0.48	8.7	8	15.57

Description:	Sample 30Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.05	4	0.528	9.6	8	15.85
2	2.05	4	0.528	9.6	8	15.85
3	2.05	4	0.528	9.6	8	15.85
4	2.06	4	0.528	9.6	8	15.85
5	2.06	4	0.528	9.6	8	15.85
6	2.06	4	0.528	9.6	8	15.85

Description:	Sample 30Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.92	4	0.578	10.5	8	14.56
2	1.92	4	0.577	10.5	8	14.57
3	1.92	4	0.577	10.5	8	14.58
4	1.86	4	0.559	10.2	8	14.58
5	1.86	4	0.559	10.2	8	14.58
6	1.85	4	0.56	10.2	8	14.54

Table A.1 (cont'd.)

Description:	Sample 30Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.43	4	0.54	9.8	8	13.02
2	1.42	4	0.539	9.8	8	12.99
3	1.44	4	0.54	9.8	8	13.03
5	1.35	4	0.511	9.3	8	12.99
6	1.35	4	0.51	9.3	8	13.02
7	1.35	4	0.51	9.3	8	13.02

Description:	Sample 30Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.66	4	0.553	10.1	8	13.85
2	1.66	4	0.554	10.1	8	13.85
3	1.66	4	0.553	10.1	8	13.86
4	1.64	4	0.546	9.9	8	13.86
5	1.64	4	0.546	9.9	8	13.85
6	1.65	4	0.545	9.9	8	13.88

Description:	Sample 31Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.57	2	0.627	11.4	8	16.11
2	2.57	2	0.627	11.4	8	16.13
3	2.57	2	0.627	11.4	8	16.13
4	2.55	2	0.625	11.4	8	16.11
5	2.56	2	0.627	11.4	8	16.11
6	2.56	2	0.627	11.4	8	16.11

Description:	Sample 31Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.36	3	0.635	11.6	8	15.35
2	2.36	3	0.634	11.5	8	15.36
3	2.34	3	0.632	11.5	8	15.33
4	2.53	2	0.678	12.3	8	15.4
5	2.54	2	0.679	12.4	8	15.4
6	2.53	2	0.678	12.3	8	15.4

Table A.1 (cont'd.)

Description:	Sample 31Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.29	3	0.636	11.6	8	15.13
2	2.31	3	0.637	11.6	8	15.15
3	2.31	3	0.637	11.6	8	15.15
4	2.3	3	0.636	11.6	8	15.14
5	2.3	3	0.639	11.6	8	15.13
6	2.31	3	0.637	11.6	8	15.15

Description:	Sample 31Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.697	12.7	8	14.63
2	2.35	3	0.696	12.7	8	14.65
3	2.35	3	0.694	12.6	8	14.65
4	2.36	3	0.698	12.7	8	14.64
5	2.36	3	0.697	12.7	8	14.66
6	2.36	3	0.696	12.7	8	14.66

Description:	Sample 31Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.9	4	0.749	13.6	8	12.68
2	1.9	4	0.749	13.6	8	12.69
3	1.89	4	0.749	13.6	8	12.67
4	1.9	4	0.75	13.6	8	12.69
5	1.9	4	0.749	13.6	8	12.69
6	1.9	4	0.749	13.6	8	12.7

Description:	Sample 31Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.68	4	0.667	12.1	8	12.67
2	1.7	4	0.669	12.2	8	12.7
3	1.7	4	0.669	12.2	8	12.7
4	1.7	4	0.669	12.2	8	12.7
5	1.69	4	0.667	12.1	8	12.68
6	1.7	4	0.668	12.2	8	12.7

Table A.1 (cont'd.)

Description:	Sample 32Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.57	2	0.673	12.1	7.9	15.86
2	2.57	2	0.674	12.1	7.9	15.87
3	2.57	2	0.674	12.1	7.9	15.87
4	2.52	2	0.66	11.9	7.9	15.87
5	2.52	2	0.662	11.9	7.9	15.86
6	2.52	2	0.66	11.9	7.9	15.88

Description:	Sample 32Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.91	4	0.617	11.1	7.9	14.28
2	1.89	4	0.616	11.1	7.9	14.23
3	1.91	4	0.617	11.1	7.9	14.27
4	1.99	4	0.645	11.6	7.9	14.27
5	1.99	4	0.645	11.6	7.9	14.28
6	1.98	4	0.644	11.6	7.9	14.25

Description:	Sample 32Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.91	4	0.617	11.1	7.9	14.28
2	1.89	4	0.616	11.1	7.9	14.23
3	1.91	4	0.617	11.1	7.9	14.27
4	1.99	4	0.645	11.6	7.9	14.27
5	1.99	4	0.645	11.6	7.9	14.28
6	1.98	4	0.644	11.6	7.9	14.25

Description:	Sample 32Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.45	2	0.591	10.7	8	16.27
2	2.45	2	0.589	10.7	8	16.29
3	2.38	3	0.574	10.4	8	16.27
4	2.38	3	0.575	10.5	8	16.25
5	2.38	3	0.574	10.4	8	16.27
6	2.38	3	0.574	10.4	8	16.27

Table A.1 (cont'd.)

Description:	Sample 32Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.18	3	0.577	10.5	8	15.53
2	2.19	3	0.575	10.5	8	15.57
3	2.19	3	0.575	10.5	8	15.57
4	2.2	3	0.586	10.7	8	15.5
5	2.21	3	0.588	10.7	8	15.5
6	2.21	3	0.587	10.7	8	15.51

Description:	Sample 32Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.76	1	0.616	11.2	8	16.91
2	2.78	1	0.617	11.2	8	16.95
3	2.78	1	0.617	11.2	8	16.96
4	2.74	1	0.613	11.2	8	16.88
5	2.73	1	0.612	11.1	8	16.86
6	2.74	1	0.612	11.1	8	16.89

Description:	Sample 33Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.7	1	0.763	13.9	8	17.55
2	3.7	1	0.763	13.9	8	17.55
3	3.72	1	0.761	13.9	8	17.61
4	3.44	1	0.732	13.3	8	17.27
5	3.46	1	0.732	13.3	8	17.32
6	3.45	1	0.731	13.3	8	17.32

Description:	Sample 33Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.42	1	0.729	13.3	8	17.27
2	3.44	1	0.729	13.3	8	17.33
3	3.42	1	0.727	13.2	8	17.29
4	3.5	1	0.751	13.7	8	17.2
5	3.52	1	0.75	13.6	8	17.25
6	3.52	1	0.75	13.6	8	17.26

Table A.1 (cont'd.)

Description:	Sample 33Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.5	1	0.711	12.9	8	17.69
2	3.49	1	0.711	12.9	8	17.66
3	3.52	1	0.713	13	8	17.7
4	3.03	1	0.718	13.1	8	16.36
5	3.54	1	0.732	13.3	8	17.52
6	3.54	1	0.732	13.3	8	17.52

Description:	Sample 33Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.63	1	0.75	13.6	8	17.54
2	3.64	1	0.75	13.6	8	17.55
3	3.6	1	0.749	13.6	8	17.48
4	3.69	1	0.759	13.8	8	17.58
5	3.67	1	0.759	13.8	8	17.53
6	3.7	1	0.759	13.8	8	17.59

Description:	Sample 33Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.75	1	0.778	14.2	8	17.51
2	3.74	1	0.779	14.2	8	17.45
3	3.76	1	0.778	14.2	8	17.51
4	3.67	1	0.779	14.2	8	17.3
5	3.68	1	0.78	14.2	8	17.31
6	3.69	1	0.78	14.2	8	17.34

Description:	Sample 33Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.58	1	0.758	13.8	8	17.32
2	3.58	1	0.758	13.8	8	17.33
3	3.58	1	0.758	13.8	8	17.32
4	3.57	1	0.759	13.8	8	17.29
5	3.55	1	0.759	13.8	8	17.24
6	3.58	1	0.758	13.8	8	17.33

Table A.1 (cont'd.)

Description:	Sample 34Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.08	4	0.54	9.8	8	15.59
2	2.08	4	0.54	9.8	8	15.59
3	2.08	4	0.54	9.8	8	15.59
4	2.09	4	0.54	9.8	8	15.59
5	1.99	4	0.54	9.8	8	15.59
6	2.01	4	0.54	9.8	8	15.59

Description:	Sample 34Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.14	3	0.551	10	8	15.63
2	2.14	3	0.551	10	8	15.63
3	2.14	3	0.551	10	8	15.63
4	2.09	3	0.551	10	8	15.63
5	2.09	3	0.551	10	8	15.63
6	2.09	3	0.551	10	8	15.63

Description:	Sample 34Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.5	2	0.583	10.6	8	16.44
2	2.5	2	0.583	10.6	8	16.44
3	2.5	2	0.583	10.6	8	16.44
4	2.38	2	0.583	10.6	8	16.47
5	2.38	2	0.583	10.6	8	16.47
6	2.38	2	0.583	10.6	8	16.47

Description:	Sample 34Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.79	1	0.631	11.5	8	16.8
2	2.81	1	0.634	11.5	8	16.84
3	2.8	1	0.634	11.5	8	16.8
4	2.86	1	0.649	11.8	8	16.77
5	2.89	1	0.65	11.8	8	16.83
6	2.89	1	0.65	11.8	8	16.84

Table A.1 (cont'd.)

Description:	Sample 34Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.597	10.9	8	16.32
2	2.48	2	0.598	10.9	8	16.28
3	2.49	2	0.597	10.9	8	16.33
4	2.6	2	0.625	11.4	8	16.29
5	2.61	1	0.625	11.4	8	16.34
6	2.61	1	0.624	11.3	8	16.36

Description:	Sample 34Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.34	3	0.575	10.5	8	16.12
2	2.33	3	0.575	10.5	8	16.08
3	2.35	3	0.577	10.5	8	16.12
4	2.42	2	0.6	10.9	8	16.06
5	2.43	2	0.596	10.8	8	16.14
6	2.44	2	0.596	10.8	8	16.16

Description:	Sample 35Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.13	3	0.693	12.6	8	14.07
2	2.13	3	0.693	12.6	8	14.06
3	2.13	3	0.693	12.6	8	14.07
4	2	4	0.655	11.9	8	14
5	2	4	0.657	11.9	8	14.01
6	1.99	4	0.655	11.9	8	13.97

Description:	Sample 35Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.32	3	0.738	13.4	8	14.24
2	2.33	3	0.736	13.4	8	14.27
3	2.33	3	0.736	13.4	8	14.27
4	2.2	3	0.684	12.4	8	14.38
5	2.2	3	0.683	12.4	8	14.39
6	2.2	3	0.683	12.4	8	14.39

Table A.1 (cont'd.)

Description:	Sample 35Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.2	3	0.602	11	8	15.22
2	2.22	3	0.603	11	8	15.28
3	2.2	3	0.603	11	8	15.22
4	2.19	3	0.601	10.9	8	15.21
5	2.18	3	0.601	10.9	8	15.19
6	2.19	3	0.601	10.9	8	15.21

Description:	Sample 35Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.25	3	0.616	11.2	8	15.23
2	2.25	3	0.615	11.2	8	15.24
3	2.24	3	0.615	11.2	8	15.21
4	2.25	3	0.624	11.3	8	15.14
5	2.23	3	0.622	11.3	8	15.09
6	2.25	3	0.624	11.3	8	15.13

Description:	Sample 35Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.615	11.2	8	16.05
2	2.5	2	0.615	11.2	8	16.06
3	2.49	2	0.615	11.2	8	16.05
4	2.53	2	0.627	11.4	8	15.99
5	2.54	2	0.627	11.4	8	16.04
6	2.54	2	0.627	11.4	8	16.05

Description:	Sample 36Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.89	4	0.597	10.8	8	14.28
2	1.87	4	0.596	10.8	8	14.23
3	1.89	4	0.597	10.8	8	14.26
4	1.97	4	0.626	11.4	8	14.25
5	1.96	4	0.626	11.4	8	14.21
6	1.98	4	0.626	11.4	8	14.27

Table A.1 (cont'd.)

Description:	Sample 36Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.05	4	0.706	12.8	8	13.58
2	2.05	4	0.705	12.8	8	13.59
3	2.05	4	0.703	12.8	8	13.6
4	1.98	4	0.675	12.3	8	13.66
5	1.98	4	0.675	12.3	8	13.65
6	1.99	4	0.675	12.3	8	13.69

Description:	Sample 36Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.87	4	0.713	13	8	12.91
2	1.87	4	0.712	13	8	12.9
3	1.87	4	0.713	13	8	12.91
4	1.76	4	0.67	12.2	8	12.91
5	1.76	4	0.672	12.2	8	12.91
6	1.75	4	0.67	12.2	8	12.87

Description:	Sample 36Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.42	2	0.687	12.5	8	14.95
2	2.42	2	0.688	12.5	8	14.96
3	2.41	2	0.687	12.5	8	14.94
4	2.4	3	0.682	12.4	8	14.95
5	2.4	3	0.682	12.4	8	14.95
6	2.4	3	0.682	12.4	8	14.94

Description:	Sample 37Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.04	1	0.707	12.9	8	16.53
2	3.04	1	0.707	12.9	8	16.53
3	3.05	1	0.706	12.8	8	16.56
4	2.95	1	0.684	12.4	8	16.55
5	2.95	1	0.686	12.5	8	16.53
6	2.95	1	0.684	12.4	8	16.56

Table A.1 (cont'd.)

Description:	Sample 37Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.58	2	0.72	13.1	8	15.08
2	2.58	2	0.72	13.1	8	15.08
3	2.59	2	0.718	13.1	8	15.13
4	2.42	2	0.675	12.3	8	15.08
5	2.41	2	0.675	12.3	8	15.06
6	2.42	2	0.674	12.3	8	15.09

Description:	Sample 37Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.5	2	0.694	12.6	8	15.12
2	2.49	2	0.693	12.6	8	15.1
3	2.5	2	0.693	12.6	8	15.13
4	2.48	2	0.688	12.5	8	15.14
5	2.48	2	0.688	12.5	8	15.14
6	2.48	2	0.688	12.5	8	15.12

Description:	Sample 38Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.06	4	0.588	10.7	8	15.02
2	2.08	4	0.588	10.7	8	15.08
3	2.08	4	0.589	10.7	8	15.06
4	2.13	3	0.602	10.9	8	15.08
5	2.12	3	0.601	10.9	8	15.08
6	2.12	3	0.601	10.9	8	15.08

Description:	Sample 38Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.14	3	0.588	10.7	8	15.31
2	2.13	3	0.588	10.7	8	15.28
3	2.14	3	0.588	10.7	8	15.31
4	2.2	3	0.603	11	8	15.32
5	2.19	3	0.603	11	8	15.3
6	2.2	3	0.603	11	8	15.31

Table A.1 (cont'd.)

Description:	Sample 38Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.26	3	0.541	9.8	8	16.28
2	2.27	3	0.54	9.8	8	16.33
3	2.26	3	0.54	9.8	8	16.31
4	2.34	3	0.554	10.1	8	16.36
5	2.34	3	0.555	10.1	8	16.35
6	2.35	3	0.555	10.1	8	16.38

Description:	Sample 38Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.22	3	0.534	9.7	8	16.25
2	2.23	3	0.532	9.7	8	16.29
3	2.23	3	0.532	9.7	8	16.29
4	2.33	3	0.558	10.1	8	16.29
5	2.33	3	0.558	10.1	8	16.29
6	2.32	3	0.559	10.2	8	16.24

Description:	Sample 38Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.548	10	8	16.8
2	2.43	2	0.548	10	8	16.79
3	2.41	2	0.546	9.9	8	16.75
4	2.49	2	0.562	10.2	8	16.79
5	2.48	2	0.562	10.2	8	16.75
6	2.48	2	0.56	10.2	8	16.75

Description:	Sample 39Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.01	4	0.508	9.2	8	15.94
2	2.01	4	0.508	9.2	8	15.97
3	2.01	4	0.508	9.2	8	15.95
4	2.03	4	0.511	9.3	8	16.01
5	2.03	4	0.511	9.3	8	16.01
6	2.01	4	0.51	9.3	8	15.95

Table A.1 (cont'd.)

Description:	Sample 39Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.53	9.6	8	15.94
2	2.11	3	0.527	9.6	8	15.95
3	2.14	3	0.529	9.6	8	16.02
4	2.18	3	0.544	9.9	8	15.96
5	2.19	3	0.543	9.9	8	16
6	2.19	3	0.544	9.9	8	15.98

Description:	Sample 39Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.26	3	0.526	9.6	8	16.53
2	2.27	3	0.525	9.6	8	16.58
3	2.27	3	0.525	9.6	8	16.56
4	2.29	3	0.527	9.6	8	16.59
5	2.27	3	0.527	9.6	8	16.54
6	2.3	3	0.529	9.6	8	16.63

Description:	Sample 39Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.4	2	0.56	10.2	8	16.5
2	2.4	2	0.56	10.2	8	16.5
3	2.38	3	0.559	10.2	8	16.45
4	2.38	3	0.559	10.2	8	16.44
5	2.39	3	0.56	10.2	8	16.45
6	2.4	3	0.56	10.2	8	16.48

Description:	Sample 40Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.31	3	0.581	10.5	8	16.02
2	2.32	3	0.579	10.5	8	16.06
3	2.31	3	0.581	10.5	8	16
4	2.24	3	0.568	10.3	8	15.93
5	2.23	3	0.567	10.3	8	15.93
6	2.25	3	0.567	10.3	8	16

Table A.1 (cont'd.)

Description:	Sample 40Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.559	10.1	8	15.34
2	2.03	4	0.558	10.1	8	15.32
3	2.03	4	0.559	10.1	8	15.31
4	2.03	4	0.559	10.1	8	15.3
5	2.02	4	0.559	10.1	8	15.25
6	2.03	4	0.559	10.1	8	15.31

Description:	Sample 40Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.14	3	0.563	10.2	8	15.63
2	2.15	3	0.564	10.2	8	15.65
3	2.15	3	0.564	10.2	8	15.65
4	2.04	4	0.541	9.8	8	15.59
5	2.05	4	0.541	9.8	8	15.6
6	2.03	4	0.541	9.8	8	15.56

Description:	Sample 40Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.19	3	0.616	11.2	8	15.02
2	2.19	3	0.617	11.2	8	15.02
3	2.19	3	0.617	11.2	8	15
4	2.17	3	0.61	11.1	8	15.05
5	2.17	3	0.608	11.1	8	15.04
6	2.17	3	0.608	11.1	8	15.04

Description:	Sample 40Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.92	4	0.62	11.3	8	14.03
2	1.92	4	0.62	11.3	8	14.03
3	1.92	4	0.62	11.3	8	14.03
4	1.87	4	0.607	11	8	13.98
5	1.87	4	0.607	11	8	13.99
6	1.87	4	0.607	11	8	13.99

Table A.1 (cont'd.)

Description:	Sample 40Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.45	2	0.621	11.3	8	15.82
2	2.46	2	0.622	11.3	8	15.84
3	2.46	2	0.622	11.3	8	15.83
4	2.42	2	0.617	11.2	8	15.77
5	2.41	2	0.615	11.2	8	15.78
6	2.43	2	0.615	11.2	8	15.83

Description:	Sample 41Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.63	4	0.5	9.1	8	14.41
2	1.63	4	0.5	9.1	8	14.41
3	1.63	4	0.5	9.1	8	14.41
4	1.58	4	0.483	8.8	8	14.4
5	1.58	4	0.484	8.8	8	14.38
6	1.58	4	0.484	8.8	8	14.41

Description:	Sample 41Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2	4	0.53	9.6	8	15.48
2	2.01	4	0.53	9.6	8	15.5
3	2.01	4	0.53	9.6	8	15.5
4	1.87	4	0.506	9.2	8	15.31
5	1.89	4	0.506	9.2	8	15.4
6	1.89	4	0.506	9.2	8	15.4

Description:	Sample 41Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.15	3	0.515	9.4	8	16.27
2	2.17	3	0.516	9.4	8	16.33
3	2.17	3	0.516	9.4	8	16.34
4	2.1	3	0.502	9.1	8	16.3
5	2.11	3	0.502	9.1	8	16.34
6	2.11	3	0.502	9.1	8	16.33

Table A.1 (cont'd.)

Description:	Sample 41Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.29	3	0.546	9.9	8	16.3
2	2.29	3	0.546	9.9	8	16.3
3	2.28	3	0.546	9.9	8	16.28
4	2.23	3	0.539	9.8	8	16.22
5	2.23	3	0.538	9.8	8	16.22
6	2.24	3	0.538	9.8	8	16.26

Description:	Sample 41Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.81	4	0.549	10	8	14.46
2	1.82	4	0.548	10	8	14.53
3	1.81	4	0.548	10	8	14.5
4	1.76	4	0.534	9.7	8	14.49
5	1.77	4	0.535	9.7	8	14.5
6	1.76	4	0.535	9.7	8	14.47

Description:	Sample 41Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.95	4	0.524	9.5	8	15.36
2	1.96	4	0.522	9.5	8	15.42
3	1.96	4	0.524	9.5	8	15.42
4	1.88	4	0.503	9.2	8	15.41
5	1.89	4	0.505	9.2	8	15.43
6	1.89	4	0.505	9.2	8	15.43

Description:	Sample 42Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.73	4	0.636	11.6	8	13.21
2	1.72	4	0.635	11.5	8	13.22
3	1.73	4	0.636	11.6	8	13.23
4	1.72	4	0.636	11.6	8	13.2
5	1.72	4	0.636	11.6	8	13.19
6	1.72	4	0.635	11.5	8	13.21

Table A.1 (cont'd.)

Description:	Sample 42Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.11	3	0.663	12	8	14.33
2	2.11	3	0.663	12	8	14.33
3	2.12	3	0.663	12	8	14.34
4	2.03	4	0.635	11.5	8	14.36
5	2.03	4	0.635	11.5	8	14.36
6	2.03	4	0.635	11.5	8	14.36

Description:	Sample 42Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.66	1	0.655	11.9	8	16.16
2	2.66	1	0.655	11.9	8	16.16
3	2.66	1	0.655	11.9	8	16.17
4	2.68	1	0.651	11.8	8	16.26
5	2.68	1	0.651	11.8	8	16.26
6	2.67	1	0.653	11.9	8	16.22

Description:	Sample 42Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.45	2	0.612	11.1	8	15.93
2	2.44	2	0.612	11.1	8	15.92
3	2.44	2	0.613	11.2	8	15.88
4	2.42	2	0.603	11	8	15.94
5	2.41	2	0.602	11	8	15.93
6	2.41	2	0.602	11	8	15.95

Description:	Sample 42Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.619	11.3	8	15.83
2	2.46	2	0.62	11.3	8	15.86
3	2.45	2	0.62	11.3	8	15.84
4	2.55	2	0.64	11.6	8	15.9
5	2.55	2	0.64	11.6	8	15.91
6	2.55	2	0.64	11.6	8	15.92

Table A.1 (cont'd.)

Description:	Sample 42Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.53	2	0.606	11	8	16.28
2	2.53	2	0.607	11	8	16.26
3	2.52	2	0.606	11	8	16.24
4	2.64	1	0.635	11.6	8	16.25
5	2.67	1	0.637	11.6	8	16.3
6	2.66	1	0.636	11.6	8	16.3

Description:	Sample 43Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.16	3	0.62	11.3	8	14.93
2	2.17	3	0.619	11.3	8	14.96
3	2.18	3	0.619	11.3	8	14.99
4	2.13	3	0.608	11.1	8	14.96
5	2.14	3	0.61	11.1	8	14.98
6	2.14	3	0.61	11.1	8	14.99

Description:	Sample 43Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.3	4	0.659	12	8	11.22
2	1.31	4	0.66	12	8	11.25
3	1.3	4	0.662	12	8	11.2
4	1.31	4	0.667	12.1	8	11.19
5	1.31	4	0.668	12.2	8	11.21
6	1.31	4	0.668	12.2	8	11.21

Description:	Sample 43Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.5	4	0.587	10.7	8	12.77
2	1.49	4	0.587	10.7	8	12.74
3	1.5	4	0.588	10.7	8	12.78
4	1.51	4	0.592	10.8	8	12.76
5	1.51	4	0.591	10.7	8	12.77
6	1.51	4	0.589	10.7	8	12.77

Table A.1 (cont'd.)

Description:	Sample 43Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.13	3	0.564	10.2	8	15.58
2	2.15	3	0.564	10.2	8	15.65
3	2.11	3	0.564	10.2	8	15.51
4	2.22	3	0.582	10.6	8	15.68
5	2.23	3	0.582	10.6	8	15.71
6	2.23	3	0.582	10.6	8	15.7

Description:	Sample 43Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.5	4	0.575	10.4	8	12.96
2	1.49	4	0.574	10.4	8	12.92
3	1.48	4	0.574	10.4	8	12.87
4	1.55	4	0.593	10.8	8	12.95
5	1.55	4	0.592	10.7	8	12.96
6	1.55	4	0.592	10.7	8	12.96

Description:	Sample 43Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.16	3	0.565	10.3	8	15.67
2	2.16	3	0.565	10.3	8	15.69
3	2.15	3	0.565	10.3	8	15.65
4	2.22	3	0.581	10.5	8	15.67
5	2.23	3	0.581	10.5	8	15.71
6	2.23	3	0.581	10.5	8	15.72

Description:	Sample 44Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.89	4	0.478	8.7	8	15.83
2	1.89	4	0.478	8.7	8	15.83
3	1.89	4	0.478	8.7	8	15.83
4	1.96	4	0.496	9	8	15.83
5	1.96	4	0.496	9	8	15.83
6	1.95	4	0.496	9	8	15.8

Table A.1 (cont'd.)

Description:	Sample 44Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.61	4	0.488	8.9	8	14.46
2	1.6	4	0.487	8.9	8	14.44
3	1.6	4	0.487	8.9	8	14.46
4	1.58	4	0.484	8.8	8	14.41
5	1.59	4	0.483	8.8	8	14.47
6	1.59	4	0.484	8.8	8	14.42

Description:	Sample 44Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.79	4	0.478	8.7	8	15.4
2	1.77	4	0.478	8.7	8	15.34
3	1.79	4	0.478	8.7	8	15.4
4	1.75	4	0.472	8.6	8	15.33
5	1.76	4	0.474	8.6	8	15.37
6	1.76	4	0.473	8.6	8	15.37

Description:	Sample 44Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.506	9.2	8	16.36
2	2.15	3	0.507	9.2	8	16.43
3	2.15	3	0.508	9.3	8	16.42
4	2.1	3	0.502	9.1	8	16.35
5	2.11	3	0.502	9.1	8	16.39
6	2.1	3	0.501	9.1	8	16.38

Description:	Sample 44Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.85	4	0.496	9	8	15.45
2	1.86	4	0.496	9	8	15.48
3	1.86	4	0.496	9	8	15.49
4	1.89	4	0.511	9.3	8	15.38
5	1.9	4	0.51	9.3	8	15.43
6	1.89	4	0.51	9.3	8	15.38

Table A.1 (cont'd.)

Description:	Sample 44Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.89	4	0.506	9.2	8	15.44
2	1.89	4	0.506	9.2	8	15.46
3	1.9	4	0.506	9.2	8	15.47
4	1.83	4	0.497	9	8	15.32
5	1.82	4	0.495	9	8	15.32
6	1.83	4	0.496	9	8	15.36

Description:	Sample 45Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.8	4	0.519	9.4	8	14.87
2	1.79	4	0.519	9.4	8	14.84
3	1.8	4	0.52	9.5	8	14.87
4	1.73	4	0.502	9.1	8	14.82
5	1.73	4	0.5	9.1	8	14.87
6	1.72	4	0.5	9.1	8	14.83

Description:	Sample 45Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.75	4	0.546	9.9	8	14.29
2	1.73	4	0.543	9.9	8	14.25
3	1.75	4	0.545	9.9	8	14.34
4	1.74	4	0.544	9.9	8	14.3
5	1.74	4	0.543	9.9	8	14.31
6	1.74	4	0.544	9.9	8	14.28

Description:	Sample 45Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.3	3	0.565	10.3	8	16.13
2	2.31	3	0.563	10.2	8	16.17
3	2.31	3	0.564	10.3	8	16.15
4	2.24	3	0.548	10	8	16.17
5	2.26	3	0.55	10	8	16.18
6	2.25	3	0.55	10	8	16.17

Table A.1 (cont'd.)

Description:	Sample 46Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.25	3	0.62	11.3	8	15.23
2	2.25	3	0.622	11.3	8	15.18
3	2.26	3	0.622	11.3	8	15.22
4	2.28	3	0.626	11.4	8	15.26
5	2.29	3	0.627	11.4	8	15.27
6	2.29	3	0.626	11.4	8	15.28

Description:	Sample 46Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.32	3	0.673	12.2	8	14.83
2	2.32	3	0.672	12.2	8	14.85
3	2.33	3	0.672	12.2	8	14.87
4	2.32	3	0.67	12.2	8	14.85
5	2.32	3	0.672	12.2	8	14.85
6	2.31	3	0.672	12.2	8	14.83

Description:	Sample 46Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.68	1	0.655	11.9	8	16.16
2	2.67	1	0.654	11.9	8	16.16
3	2.68	1	0.654	11.9	8	16.18
4	2.67	1	0.656	11.9	8	16.11
5	2.67	1	0.655	11.9	8	16.12
6	2.68	1	0.654	11.9	8	16.19

Description:	Sample 47Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.18	1	0.698	12.7	8	17.04
2	3.18	1	0.698	12.7	8	17.04
3	3.18	1	0.698	12.7	8	17.06
4	3.17	1	0.698	12.7	8	17.03
5	3.15	1	0.697	12.7	8	16.99
6	3.15	1	0.697	12.7	8	16.99

Table A.1 (cont'd.)

Description:	Sample 47Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.15	3	0.653	11.9	8	14.51
2	2.15	3	0.651	11.9	8	14.52
3	2.15	3	0.653	11.9	8	14.49
4	2.14	3	0.653	11.9	8	14.48
5	2.16	3	0.653	11.9	8	14.53
6	2.16	3	0.651	11.9	8	14.54

Description:	Sample 47Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.13	3	0.668	12.2	8	14.26
2	2.12	3	0.668	12.2	8	14.25
3	2.13	3	0.669	12.2	8	14.27
4	2.09	4	0.659	12	8	14.23
5	2.08	4	0.656	11.9	8	14.22
6	2.08	4	0.658	12	8	14.22

Description:	Sample 48Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.84	1	0.672	12.2	8	16.44
2	2.82	1	0.67	12.2	8	16.39
3	2.83	1	0.67	12.2	8	16.41
4	2.83	1	0.67	12.2	8	16.42
5	2.83	1	0.672	12.2	8	16.4
6	2.84	1	0.672	12.2	8	16.43

Description:	Sample 48Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.05	1	0.711	12.9	8	16.56
2	3.04	1	0.713	13	8	16.5
3	3.05	1	0.712	13	8	16.53
4	2.98	1	0.691	12.6	8	16.6
5	2.96	1	0.688	12.5	8	16.56
6	2.98	1	0.691	12.6	8	16.61

Table A.1 (cont'd.)

Description:	Sample 48Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	3.1	1	0.688	12.5	8	16.96
2	3.08	1	0.686	12.5	8	16.93
3	3.12	1	0.687	12.5	8	17.03
4	3.16	1	0.702	12.8	8	16.95
5	3.17	1	0.705	12.8	8	16.95
6	3.16	1	0.702	12.8	8	16.96

Description:	Sample 49Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.59	2	0.581	10.6	8	16.87
2	2.6	2	0.582	10.6	8	16.88
3	2.59	2	0.581	10.6	8	16.89
4	2.6	1	0.583	10.6	8	16.87
5	2.58	2	0.582	10.6	8	16.83
6	2.59	2	0.583	10.6	8	16.83

Description:	Sample 49Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.608	11.1	8	15.71
2	2.35	3	0.606	11	8	15.72
3	2.37	3	0.607	11	8	15.78
4	2.28	3	0.593	10.8	8	15.68
5	2.3	3	0.596	10.8	8	15.69
6	2.3	3	0.596	10.8	8	15.7

Description:	Sample 49Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.41	2	0.591	10.7	8	16.15
2	2.4	3	0.591	10.7	8	16.09
3	2.41	2	0.591	10.7	8	16.13
4	2.42	2	0.592	10.8	8	16.17
5	2.42	2	0.592	10.8	8	16.17
6	2.42	2	0.592	10.8	8	16.17

Table A.1 (cont'd.)

Description:	Sample 49Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.49	2	0.55	10	8	17.01
2	2.49	2	0.55	10	8	17.02
3	2.48	2	0.55	10	8	16.99
4	2.48	2	0.549	10	8	17
5	2.49	2	0.55	10	8	17.02
6	2.47	2	0.55	10	8	16.97

Description:	Sample 49Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.44	2	0.568	10.3	8	16.64
2	2.46	2	0.569	10.3	8	16.67
3	2.45	2	0.569	10.3	8	16.64
4	2.52	2	0.582	10.6	8	16.69
5	2.53	2	0.581	10.5	8	16.76
6	2.51	2	0.581	10.5	8	16.7

Description:	Sample 49Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.31	3	0.574	10.4	8	16.08
2	2.31	3	0.573	10.4	8	16.12
3	2.31	3	0.573	10.4	8	16.13
4	2.3	3	0.577	10.5	8	16.03
5	2.32	3	0.578	10.5	8	16.09
6	2.33	3	0.578	10.5	8	16.1

Description:	Sample 50Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.75	4	0.57	10.4	8	13.99
2	1.75	4	0.568	10.3	8	14.04
3	1.74	4	0.568	10.3	8	14
4	1.75	4	0.57	10.4	8	13.98
5	1.74	4	0.567	10.3	8	14
6	1.75	4	0.568	10.3	8	14.03

Table A.1 (cont'd.)

Description:	Sample 50Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.8	4	0.538	9.8	8	14.61
2	1.79	4	0.536	9.8	8	14.58
3	1.8	4	0.538	9.8	8	14.63
4	1.81	4	0.543	9.9	8	14.6
5	1.82	4	0.543	9.9	8	14.61
6	1.81	4	0.541	9.8	8	14.61

Description:	Sample 51Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.43	4	0.51	9.3	8	13.37
2	1.44	4	0.511	9.3	8	13.42
3	1.44	4	0.511	9.3	8	13.4
4	1.36	4	0.517	9.4	8	12.94
5	1.43	4	0.51	9.3	8	13.39
6	1.44	4	0.51	9.3	8	13.42

Description:	Sample 51Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.19	4	0.506	9.2	8	12.26
2	1.19	4	0.506	9.2	8	12.27
3	1.19	4	0.505	9.2	8	12.27
4	1.2	4	0.51	9.3	8	12.24
5	1.2	4	0.51	9.3	8	12.26
6	1.2	4	0.508	9.3	8	12.26

Description:	Sample 51Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.33	4	0.525	9.6	8	12.72
2	1.33	4	0.525	9.6	8	12.73
3	1.34	4	0.526	9.6	8	12.76
4	1.34	4	0.529	9.6	8	12.71
5	1.34	4	0.529	9.6	8	12.71
6	1.34	4	0.529	9.6	8	12.71

Table A.1 (cont'd.)

Description:	Sample 52Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.56	2	0.681	12.4	8	15.57
2	2.54	2	0.681	12.4	8	15.51
3	2.55	2	0.681	12.4	8	15.54
4	2.47	2	0.662	12	8	15.51
5	2.46	2	0.662	12	8	15.48
6	2.46	2	0.662	12	8	15.47

Description:	Sample 52Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.09	4	0.622	11.3	8	14.59
2	2.1	4	0.621	11.3	8	14.64
3	2.09	4	0.621	11.3	8	14.63
4	1.97	4	0.586	10.7	8	14.6
5	1.95	4	0.583	10.6	8	14.57
6	1.96	4	0.584	10.6	8	14.61

Description:	Sample 52Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2	4	0.589	10.7	8	14.68
2	1.99	4	0.589	10.7	8	14.65
3	2	4	0.589	10.7	8	14.68
4	1.98	4	0.581	10.6	8	14.71
5	1.97	4	0.581	10.6	8	14.68
6	1.98	4	0.581	10.6	8	14.7

Description:	Sample 53Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.54	4	0.515	9.4	8	13.76
2	1.54	4	0.514	9.3	8	13.82
3	1.54	4	0.514	9.3	8	13.8
4	1.52	4	0.506	9.2	8	13.81
5	1.52	4	0.503	9.2	8	13.83
6	1.52	4	0.505	9.2	8	13.83

Table A.1 (cont'd.)

Description:	Sample 53Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.53	4	0.479	8.7	8	14.26
2	1.52	4	0.478	8.7	8	14.23
3	1.53	4	0.478	8.7	8	14.27
4	1.56	4	0.481	8.7	8	14.33
5	1.56	4	0.482	8.8	8	14.32
6	1.56	4	0.482	8.8	8	14.34

Description:	Sample 53Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.88	4	0.52	9.5	8	15.15
2	1.88	4	0.52	9.5	8	15.13
3	1.88	4	0.521	9.5	8	15.13
4	2.02	4	0.524	9.5	8	15.63
5	2.01	4	0.524	9.5	8	15.63
6	2.01	4	0.524	9.5	8	15.61

Description:	Sample 53Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.87	4	0.544	9.9	8	14.77
2	1.87	4	0.543	9.9	8	14.79
3	1.87	4	0.544	9.9	8	14.78
4	1.78	4	0.52	9.5	8	14.76
5	1.79	4	0.52	9.5	8	14.77
6	1.8	4	0.521	9.5	8	14.83

Description:	Sample 53Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.79	4	0.52	9.5	8	14.79
2	1.79	4	0.519	9.4	8	14.8
3	1.79	4	0.519	9.4	8	14.79
4	1.72	4	0.505	9.2	8	14.73
5	1.72	4	0.505	9.2	8	14.73
6	1.73	4	0.505	9.2	8	14.75

Table A.1 (cont'd.)

Description:	Sample 53Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.74	4	0.543	9.9	8	14.26
2	1.74	4	0.543	9.9	8	14.26
3	1.74	4	0.543	9.9	8	14.26
4	1.69	4	0.532	9.7	8	14.21
5	1.69	4	0.532	9.7	8	14.21
6	1.69	4	0.532	9.7	8	14.2

Description:	Sample 54Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.54	4	0.593	10.8	8	12.83
2	1.54	4	0.593	10.8	8	12.83
3	1.54	4	0.592	10.8	8	12.83
4	1.57	4	0.606	11	8	12.84
5	1.57	4	0.606	11	8	12.84
6	1.57	4	0.606	11	8	12.84

Description:	Sample 54Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.17	4	0.62	11.3	8	10.93
2	1.17	4	0.621	11.3	8	10.92
3	1.17	4	0.621	11.3	8	10.92
4	1.16	4	0.619	11.3	8	10.92
5	1.17	4	0.62	11.3	8	10.93
6	1.16	4	0.62	11.3	8	10.92

Description:	Sample 54Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.5	4	0.65	11.8	8	12.18
2	1.5	4	0.65	11.8	8	12.19
3	1.5	4	0.65	11.8	8	12.18
4	1.45	4	0.63	11.4	8	12.16
5	1.45	4	0.629	11.4	8	12.17
6	1.46	4	0.63	11.4	8	12.22

Table A.1 (cont'd.)

Description:	Sample 55Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.59	2	0.66	12	8	15.88
2	2.6	2	0.66	12	8	15.92
3	2.6	2	0.66	12	8	15.91
4	2.5	2	0.688	12.5	8	15.29
5	2.5	2	0.687	12.5	8	15.31
6	2.5	2	0.687	12.5	8	15.3

Description:	Sample 55Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.35	3	0.688	12.5	8	14.73
2	2.37	3	0.691	12.6	8	14.77
3	2.37	3	0.689	12.5	8	14.77
4	2.45	2	0.717	13	8	14.73
5	2.45	2	0.715	13	8	14.75
6	2.45	2	0.715	13	8	14.74

Description:	Sample 55Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.7	1	0.682	12.4	8	15.98
2	2.71	1	0.682	12.4	8	16
3	2.7	1	0.682	12.4	8	15.97
4	2.85	1	0.717	13	8	15.99
5	2.84	1	0.717	13	8	15.98
6	2.88	1	0.717	13	8	16.09

Description:	Sample 56Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2	4	0.612	11.1	8	14.47
2	2.01	4	0.613	11.1	8	14.5
3	2.02	4	0.614	11.2	8	14.5
4	1.98	4	0.603	11	8	14.51
5	1.98	4	0.605	11	8	14.48
6	1.99	4	0.604	11	8	14.52

Table A.1 (cont'd.)

Description:	Sample 56Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.98	4	0.605	11	8	14.42
2	1.99	4	0.606	11	8	14.43
3	1.99	4	0.605	11	8	14.46
4	2.01	4	0.625	11.4	8	14.28
5	2.04	4	0.621	11.3	8	14.43
6	2.04	4	0.621	11.3	8	14.44

Description:	Sample 56Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.98	4	0.569	10.4	8	14.88
2	1.99	4	0.57	10.4	8	14.89
3	1.98	4	0.57	10.4	8	14.85
4	2.09	4	0.594	10.8	8	14.93
5	2.08	4	0.594	10.8	8	14.91
6	2.1	4	0.594	10.8	8	14.96

Description:	Sample 56Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.51	2	0.616	11.2	8	16.08
2	2.51	2	0.615	11.2	8	16.1
3	2.51	2	0.616	11.2	8	16.09
4	2.47	2	0.612	11.1	8	16.02
5	2.46	2	0.611	11.1	8	15.97
6	2.48	2	0.612	11.1	8	16.03

Description:	Sample 56Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.19	3	0.662	12	8	14.64
2	2.19	3	0.662	12	8	14.63
3	2.19	3	0.664	12	8	14.62
4	2.19	3	0.664	12	8	14.64
5	2.18	3	0.662	12	8	14.61
6	2.18	3	0.662	12	8	14.61

Table A.1 (cont'd.)

Description:	Sample 56Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.58	2	0.703	12.7	8	15.43
2	2.59	2	0.704	12.7	8	15.45
3	2.58	2	0.704	12.7	8	15.4
4	2.58	2	0.703	12.7	8	15.43
5	2.57	2	0.706	12.8	8	15.37
6	2.59	2	0.706	12.8	8	15.42

Description:	Sample 57Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.33	4	0.559	10.2	8	12.3
2	1.33	4	0.56	10.2	8	12.31
3	1.33	4	0.559	10.2	8	12.31
4	1.33	4	0.559	10.2	8	12.3
5	1.33	4	0.559	10.2	8	12.27
6	1.32	4	0.559	10.2	8	12.27

Description:	Sample 57Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.5	4	0.554	10.1	8	13.16
2	1.47	4	0.554	10.1	8	13.01
3	1.45	4	0.554	10.1	8	12.91
4	1.4	4	0.527	9.6	8	13.04
5	1.4	4	0.527	9.6	8	13.02
6	1.4	4	0.526	9.6	8	13.04

Description:	Sample 57Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.77	4	0.541	9.8	8	14.43
2	1.77	4	0.541	9.8	8	14.44
3	1.76	4	0.54	9.8	8	14.43
4	1.8	4	0.557	10.1	8	14.39
5	1.81	4	0.559	10.2	8	14.39
6	1.8	4	0.557	10.1	8	14.38

Table A.1 (cont'd.)

Description:	Sample 58Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.669	12.2	8	13.91
2	2.04	4	0.67	12.2	8	13.91
3	2.04	4	0.669	12.2	8	13.91
4	1.96	4	0.64	11.6	8	13.94
5	1.96	4	0.64	11.6	8	13.96
6	1.95	4	0.64	11.6	8	13.92

Description:	Sample 58Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.37	4	0.617	11.2	8	11.86
2	1.36	4	0.617	11.2	8	11.85
3	1.36	4	0.617	11.2	8	11.82
4	1.36	4	0.616	11.2	8	11.84
5	1.36	4	0.616	11.2	8	11.85
6	1.36	4	0.616	11.2	8	11.85

Description:	Sample 58Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.76	4	0.673	12.2	8	12.88
2	1.76	4	0.672	12.2	8	12.89
3	1.75	4	0.672	12.2	8	12.87
4	1.77	4	0.677	12.3	8	12.89
5	1.77	4	0.678	12.3	8	12.87
6	1.76	4	0.677	12.3	8	12.86

Description:	Sample 58Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.38	3	0.637	11.4	7.9	15.89
2	2.37	3	0.637	11.4	7.9	15.86
3	2.38	3	0.637	11.4	7.9	15.9
4	2.36	3	0.636	11.4	7.9	15.85
5	2.35	3	0.636	11.4	7.9	15.83
6	2.35	3	0.636	11.4	7.9	15.83

Table A.1 (cont'd.)

Description:	Sample 58Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.11	3	0.582	10.6	8	15.19
2	2.11	3	0.581	10.6	8	15.2
3	2.1	3	0.581	10.6	8	15.17
4	2.11	3	0.582	10.6	8	15.19
5	2.11	3	0.581	10.6	8	15.19
6	2.11	3	0.581	10.6	8	15.19

Description:	Sample 58Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.99	4	0.584	10.6	8	14.7
2	1.99	4	0.584	10.6	8	14.7
3	2	4	0.586	10.7	8	14.71
4	1.99	4	0.583	10.6	8	14.7
5	2	4	0.583	10.6	8	14.75
6	2	4	0.583	10.6	8	14.75

Description:	Sample 59Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.73	4	0.594	10.8	8	13.62
2	1.72	4	0.594	10.8	8	13.59
3	1.73	4	0.594	10.8	8	13.62
4	1.66	4	0.582	10.6	8	13.49
5	1.65	4	0.579	10.5	8	13.49
6	1.66	4	0.581	10.6	8	13.5

Description:	Sample 59Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.58	4	0.639	11.6	8	12.56
2	1.59	4	0.64	11.6	8	12.58
3	1.59	4	0.64	11.6	8	12.59
4	1.46	4	0.593	10.8	8	12.52
5	1.43	4	0.591	10.7	8	12.42
6	1.43	4	0.593	10.8	8	12.42

Table A.1 (cont'd.)

Description:	Sample 59Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.46	4	0.584	10.6	8	12.63
2	1.46	4	0.584	10.6	8	12.63
3	1.47	4	0.586	10.7	8	12.64
5	1.44	4	0.589	10.7	8	12.48
6	1.44	4	0.588	10.7	8	12.52

Description:	Sample 60Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.1	3	0.581	10.6	8	15.21
2	2.11	3	0.578	10.5	8	15.27
3	2.11	3	0.578	10.5	8	15.27
4	2.08	4	0.593	10.8	8	14.97
5	2.15	3	0.592	10.8	8	15.24
6	2.15	3	0.592	10.8	8	15.24

Description:	Sample 60Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.3	3	0.579	10.5	8	15.91
2	2.3	3	0.578	10.5	8	15.93
3	2.3	3	0.579	10.5	8	15.93
4	2.4	2	0.606	11	8	15.91
5	2.41	2	0.606	11	8	15.92
6	2.41	2	0.606	11	8	15.93

Description:	Sample 60Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.82	1	0.602	11	8	17.29
2	2.81	1	0.6	10.9	8	17.29
3	2.82	1	0.602	11	8	17.29
4	2.78	1	0.596	10.8	8	17.25
5	2.78	1	0.594	10.8	8	17.27
6	2.79	1	0.594	10.8	8	17.3

Table A.1 (cont'd.)

Description:	Sample 61Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.7	1	0.659	12	8	16.16
2	2.7	1	0.659	12	8	16.18
3	2.69	1	0.66	12	8	16.14
4	2.57	2	0.629	11.4	8	16.14
5	2.57	2	0.629	11.4	8	16.16
6	2.56	2	0.627	11.4	8	16.14

Description:	Sample 61Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.27	3	0.664	12.1	8	14.79
2	2.28	3	0.665	12.1	8	14.8
3	2.28	3	0.664	12.1	8	14.8
4	2.28	3	0.664	12.1	8	14.81
5	2.28	3	0.664	12.1	8	14.79
6	2.26	3	0.664	12.1	8	14.75

Description:	Sample 62Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.62	4	0.472	8.5	8	14.93
2	1.63	4	0.472	8.5	8	14.98
3	1.63	4	0.472	8.5	8	14.98
4	1.63	4	0.472	8.5	8	14.97
5	1.62	4	0.472	8.5	8	14.93
6	1.63	4	0.472	8.5	8	14.97

Description:	Sample 62Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.58	4	0.534	9.7	8	13.71
2	1.58	4	0.532	9.7	8	13.74
3	1.58	4	0.532	9.7	8	13.71
4	1.61	4	0.543	9.9	8	13.74
5	1.61	4	0.543	9.9	8	13.75
6	1.62	4	0.543	9.9	8	13.76

Table A.1 (cont'd.)

Description:	Sample 62Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.92	4	0.489	8.9	8	15.77
2	1.94	4	0.491	8.9	8	15.83
3	1.94	4	0.491	8.9	8	15.85
4	1.93	4	0.489	8.9	8	15.83
5	1.92	4	0.489	8.9	8	15.77
6	1.93	4	0.491	8.9	8	15.81

Description:	Sample 62Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.67	4	0.449	8.2	8	15.39
2	1.69	4	0.449	8.2	8	15.44
3	1.67	4	0.448	8.1	8	15.4
4	1.69	4	0.452	8.2	8	15.4
5	1.71	4	0.45	8.2	8	15.54
6	1.7	4	0.45	8.2	8	15.47
7	1.72	4	0.452	8.2	8	15.54

Description:	Sample 62Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.51	4	0.492	8.9	8	14
2	1.5	4	0.491	8.9	8	13.99
3	1.52	4	0.492	8.9	8	14.05
4	1.53	4	0.497	9	8	14.02
5	1.53	4	0.499	9.1	8	14.02
6	1.53	4	0.499	9.1	8	14.03

Description:	Sample 62Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.74	4	0.466	8.3	7.8	16.12
2	1.74	4	0.466	8.3	7.8	16.13
3	1.74	4	0.466	8.3	7.8	16.12
4	1.71	4	0.461	8.2	7.8	16.07
5	1.7	4	0.46	8.2	7.8	16.09
6	1.71	4	0.46	8.2	7.8	16.11

Table A.1 (cont'd.)

Description:	Sample 63Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.1	4	0.527	9.6	8	15.94
2	2.1	3	0.529	9.6	8	15.93
3	2.1	3	0.527	9.6	8	15.96
4	2.08	4	0.532	9.7	8	15.8
5	2.09	4	0.527	9.6	8	15.9
6	2.09	4	0.527	9.6	8	15.92

Description:	Sample 63Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.41	4	0.632	11.5	8	11.94
2	1.42	4	0.632	11.5	8	11.96
3	1.41	4	0.632	11.5	8	11.93
4	1.42	4	0.634	11.5	8	11.95
5	1.41	4	0.632	11.5	8	11.95
6	1.41	4	0.632	11.5	8	11.93

Description:	Sample 63Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.93	4	0.527	9.6	8	15.3
2	1.93	4	0.526	9.6	8	15.29
3	1.94	4	0.526	9.6	8	15.35
4	1.92	4	0.517	9.4	8	15.41
5	1.92	4	0.516	9.4	8	15.42
6	1.91	4	0.516	9.4	8	15.37

Description:	Sample 64Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.39	3	0.606	11	8	15.92
2	2.39	3	0.608	11	8	15.91
3	2.39	3	0.606	11	8	15.93
4	2.35	3	0.594	10.8	8	15.94
5	2.35	3	0.593	10.8	8	15.95
6	2.34	3	0.593	10.8	8	15.95

Table A.1 (cont'd.)

Description:	Sample 64Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.22	3	0.627	11.4	8	15.08
2	2.22	3	0.626	11.4	8	15.11
3	2.21	3	0.626	11.4	8	15.06
4	2.17	3	0.614	11.2	8	15.08
5	2.17	3	0.613	11.1	8	15.1
6	2.17	3	0.614	11.2	8	15.06

Description:	Sample 64Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.65	1	0.623	11.3	8	16.54
2	2.66	1	0.622	11.3	8	16.59
3	2.66	1	0.622	11.3	8	16.6
4	2.6	1	0.61	11.1	8	16.56
5	2.6	2	0.609	11.1	8	16.56
6	2.6	2	0.609	11.1	8	16.55

Description:	Sample 64Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2	4	0.699	12.7	8	13.54
2	2	4	0.699	12.7	8	13.54
3	2	4	0.699	12.7	8	13.54
4	1.91	4	0.661	12	8	13.61
5	1.9	4	0.66	12	8	13.6
6	1.91	4	0.66	12	8	13.6

Description:	Sample 65Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.24	3	0.61	11.1	8	15.3
2	2.24	3	0.61	11.1	8	15.31
3	2.24	3	0.611	11.1	8	15.29
4	2.24	3	0.61	11.1	8	15.33
5	2.24	3	0.612	11.1	8	15.3
6	2.23	3	0.61	11.1	8	15.28

Table A.1 (cont'd.)

Description:	Sample 65Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.39	4	0.567	10.3	8	12.51
2	1.38	4	0.568	10.3	8	12.46
3	1.39	4	0.567	10.3	8	12.52
4	1.36	4	0.555	10.1	8	12.51
5	1.35	4	0.554	10.1	8	12.49
6	1.37	4	0.555	10.1	8	12.56

Description:	Sample 65Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.47	4	0.565	10.3	8	12.88
2	1.46	4	0.564	10.3	8	12.86
3	1.47	4	0.564	10.3	8	12.89
4	1.47	4	0.563	10.2	8	12.89
5	1.46	4	0.564	10.3	8	12.87
6	1.46	4	0.563	10.2	8	12.89

Description:	Sample 66Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.12	3	0.526	9.6	8	16
2	2.11	3	0.525	9.6	8	15.97
3	2.12	3	0.525	9.6	8	16
4	2.12	3	0.526	9.6	8	16
5	2.11	3	0.525	9.6	8	15.97
6	2.12	3	0.525	9.6	8	16.02

Description:	Sample 66Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.95	4	0.523	9.5	8	15.44
2	1.95	4	0.523	9.5	8	15.46
3	1.95	4	0.523	9.5	8	15.45
4	2.03	4	0.542	9.8	8	15.5
5	2.04	4	0.542	9.8	8	15.5
6	2.02	4	0.541	9.8	8	15.47

Table A.1 (cont'd.)

Description:	Sample 66Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.58	4	0.491	8.9	8	14.36
2	1.58	4	0.492	8.9	8	14.34
3	1.59	4	0.492	8.9	8	14.38
4	1.63	4	0.507	9.2	8	14.36
5	1.64	4	0.508	9.2	8	14.36
6	1.63	4	0.507	9.2	8	14.36

Description:	Sample 66Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.04	4	0.512	9.3	8	16.09
2	2.05	4	0.512	9.3	8	16.09
3	2.05	4	0.512	9.3	8	16.11
4	2.12	3	0.524	9.5	8	16.2
5	2.11	3	0.523	9.5	8	16.19
6	2.12	3	0.523	9.5	8	16.21

Description:	Sample 66Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.81	4	0.498	9.1	8	15.2
2	1.81	4	0.5	9.1	8	15.16
3	1.82	4	0.5	9.1	8	15.21
4	1.9	4	0.517	9.4	8	15.27
5	1.9	4	0.519	9.4	8	15.27
6	1.91	4	0.517	9.4	8	15.29

Description:	Sample 66Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.498	9.1	8	15.21
2	1.81	4	0.497	9	8	15.21
3	1.83	4	0.498	9.1	8	15.25
4	1.74	4	0.477	8.7	8	15.21
5	1.73	4	0.478	8.7	8	15.16
6	1.74	4	0.477	8.7	8	15.21

Table A.1 (cont'd.)

Description:	Sample 67Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.13	3	0.572	10.4	8	15.42
2	2.11	3	0.569	10.4	8	15.39
3	2.12	3	0.57	10.4	8	15.4
4	2.18	3	0.573	10.4	8	15.57
5	2.17	3	0.573	10.4	8	15.56
6	2.15	3	0.57	10.4	8	15.51

Description:	Sample 67Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.598	10.9	8	13.93
2	1.81	4	0.598	10.9	8	13.89
3	1.82	4	0.598	10.9	8	13.93
4	1.75	4	0.596	10.8	8	13.71
5	1.82	4	0.598	10.9	8	13.93
6	1.82	4	0.6	10.9	8	13.93

Description:	Sample 67Ac					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.82	4	0.643	11.7	8	13.43
2	1.81	4	0.643	11.7	8	13.41
3	1.81	4	0.641	11.7	8	13.41
4	1.82	4	0.648	11.8	8	13.38
5	1.81	4	0.645	11.7	8	13.39
6	1.81	4	0.646	11.8	8	13.36

Description:	Sample 67Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.48	2	0.61	11.1	8	16.13
2	2.47	2	0.61	11.1	8	16.12
3	2.48	2	0.611	11.1	8	16.12
4	2.51	2	0.601	10.9	8	16.36
5	2.51	2	0.601	10.9	8	16.37
6	2.51	2	0.601	10.9	8	16.37

Table A.1 (cont'd.)

Description:	Sample 67Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.5	2	0.6	10.9	8	16.34
2	2.51	2	0.6	10.9	8	16.37
3	2.5	2	0.601	10.9	8	16.33
4	2.5	2	0.6	10.9	8	16.35
5	2.51	2	0.601	10.9	8	16.36
6	2.51	2	0.601	10.9	8	16.37

Description:	Sample 67Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.21	3	0.617	11.2	8	15.13
2	2.21	3	0.616	11.2	8	15.17
3	2.22	3	0.616	11.2	8	15.18
4	2.18	3	0.626	11.4	8	14.93
5	2.2	3	0.626	11.4	8	14.99
6	2.19	3	0.625	11.3	8	14.99

Description:	Sample 68Aa					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.39	3	0.552	10	8	16.63
2	2.39	3	0.552	10	8	16.62
3	2.4	3	0.551	10	8	16.65
4	2.37	3	0.543	9.9	8	16.7
5	2.38	3	0.542	9.8	8	16.72
6	2.38	3	0.543	9.9	8	16.72

Description:	Sample 68Ab					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.15	3	0.532	9.7	8	16.03
2	2.17	3	0.532	9.7	8	16.09
3	2.17	3	0.532	9.7	8	16.09
4	2.11	3	0.522	9.5	8	16.03
5	2.12	3	0.521	9.5	8	16.06
6	2.12	3	0.521	9.5	8	16.07

Table A.1 (cont'd.)

Description:	Sample 68Ba					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	2.54	2	0.568	10.1	7.8	17.79
2	2.54	2	0.568	10.1	7.8	17.79
3	2.52	2	0.568	10.1	7.8	17.72
4	2.59	2	0.574	10.2	7.8	17.88
5	2.6	1	0.574	10.2	7.8	17.9
6	2.6	1	0.574	10.2	7.8	17.9

Description:	Sample 68Bb					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.98	4	0.519	9.2	7.8	16.42
2	1.97	4	0.519	9.2	7.8	16.37
3	1.99	4	0.521	9.2	7.8	16.44
4	2.08	4	0.536	9.5	7.8	16.55
5	2.07	4	0.538	9.5	7.8	16.49
6	2.07	4	0.536	9.5	7.8	16.52

Description:	Sample 68Bc					
Pc No	E [Mpsi]	Grade	SG	Weight [lbs]	Length [ft]	Freq. [Hz]
1	1.98	4	0.544	9.6	7.8	16.04
2	1.99	4	0.544	9.6	7.8	16.07
3	1.99	4	0.544	9.6	7.8	16.06
4	1.98	4	0.544	9.6	7.8	16.05
5	1.99	4	0.544	9.6	7.8	16.07
6	1.99	4	0.544	9.6	7.8	16.06

APPENDIX B: INSTRON DATA

SR	Specimen label	Width	Thickness	Maximum Flexure load	Extension at Max.load	MOR	Modulus (Young's Flexure stress 2 mm - 3 mm)
		(mm)	(mm)	(lbf)	(mm)	(psi)	(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
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

Table A.2: Instron Readings

Table A.2 (cont'd.)

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
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

Table A.2 (cont'd.)

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
83	14BcR	25.4	25.4	819.05	14.85	17,200.05	2,099,662.13
84	60AcR	25.4	25.4	345.5	7.15	7,255.50	1,073,205.56
85	6AbR	25.4	25.4	517.85	7.96	10,874.85	1,290,088.66
86	27BbL	25.4	25.4	363.22	5.45	7,627.62	1,393,048.89
87	1BcR	25.4	25.4	796.5	12.29	16,726.50	1,809,392.27
88	47AaR	25.4	25.4	871.4	8.59	18,299.40	2,224,353.72
89	38BbM	25.4	25.4	618.52	8.39	12,988.92	1,660,874.36
90	35AbR	25.4	25.4	579.13	8.21	14,251.79	1,810,068.31

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