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02.
TALL WOOD SURVEY:
Identifying and Analyzing the Obstacles of Perception

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ABSTRACT

Tall wood buildings are becoming increasingly prevalent around the world, and yet, they are conspicuously missing from the U.S. skyline. Antiquated building code restrictions have put the United States behind its Canadian and European counterparts, preventing the U.S. from even considering the use of wood as the primary structure in a tall building. Recent initiatives from various wood manufacturers and sponsors are pushing back on these restrictions and providing the research and support needed to move engineered wood products forward.

This article aims to address the public's perception of engineered wood to determine if there are perception barriers that may be impeding advancement of tall wood buildings. The research methods included literature review and survey. The survey methodology included a web-based questionnaire, which more than 500 respondents completed.

The general survey population identified flammability as the greatest perception barrier to building tall with wood, followed by strength, deforestation, and durability. However, respondents that identified themselves as more familiar with engineered wood products characterized moisture as the greatest barrier, followed by insurance, cost, and durability. This data revealed that public education and awareness campaigns, which can help increase familiarity with building materials, may contribute towards overcoming these perception barriers and pave the way for building code revisions related to engineered wood products.

KEYWORDS: mass timber, sustainable design, building code, public awareness, education

1.0 INTRODUCTION

According to the United Nations, by the year 2050, our planet's population will rise by more than a quarter[1] and nearly 70 percent[2] will live in urban settings. Our cities are growing, but so is our environmental impact - a staggering one third of global CO_2 emissions comes from the construction and operation of buildings[3]. With this projected surge in demand for high rise buildings, and in light of the climate change crisis, we must consider materials that contribute to a more sustainable built environment – wood. Despite the fact that wood has a lighter environmental impact than today's typical high rise construction materials, it faces many obstacles, not the least of which is public perception[4].

Engineered wood products are manufactured by binding strands, fibers, or veneers of wood together with adhesives to form composite materials. Some examples of engineered wood products used for building structure include Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), Glued Laminated Timber (Glulam), and Nail Laminated Timber (NLT).

In many parts of the world, engineered wood products have been utilized as the primary structural material for high rise buildings over the past 20 years[5], but tall wood applications are only now being employed in the United States[6]. Much of this is due to outdated building codes, which limited the height of wood buildings to five

stories on a concrete podium. However, the adoption of the 2015 International Building Code (IBC) brings many new opportunities for the use of engineered wood products by incorporating updates to the 2015 National Design Specification (NDS) for Wood Construction, which now includes a chapter on Cross Laminated Timber (CLT). The code identifies CLT as a structural product allowing it to be utilized in Type IV construction of exterior walls, floors, and roofs. The 2015 NDS also provides char ratings for CLT and other engineered wood products.

These code changes would not have been possible without the research efforts of engineered wood product pioneers and advocates including Michael Green Architecture (MGA), Skidmore, Owings & Merrill (SOM), and Perkins+Will. Each of these champions has explored various aspects and challenges of tall wood buildings from code constraints to hybrid models to lessons learned on built projects.

Driven to find carbon-neutral and sustainable structural materials for North America's rapidly urbanizing population, Michael Green co-authored the feasibility study "The Case for Tall Wood Buildings"[7]. The 30-story proposal utilizes laminated strand lumber as the primary structural material, while incorporating ductile steel beams to address wind and earthquake forces. The report serves as an instruction manual for building tall with wood.

SOM's Timber Tower Research Project proposes a 42-story hybrid structural system referred to as the Concrete Jointed Timber Frame (CJTF)[8]. SOM utilized the Dewitt-Chestnutt Apartments, designed and built in 1965, as the concrete benchmark for comparison. The resulting timber proposal reduced the carbon footprint of the building by 60-75 percent and is believed to be technically feasible from a structural standpoint. However, the study states that the system requires additional research and testing to validate the performance of the structural system. Therefore, a subsequent study reported on the performance of gravity framing system, consisting of a detailed analysis of the hybrid CJTF system[9].

Forestry Innovation Investment (FII) and Binational Softwood Lumber Council (BSLC) engaged Perkins+Will to visit built tall wood projects around the world and survey the various stakeholders to collect lessons learned. The results of this survey are documented in the "Survey of International Tall Wood Buildings"[10]. The research team also summarized the findings and the most important lessons learned in a journal article titled "Lessons from Tall Wood Buildings: What We Learned from Ten International Examples"[11].

Public opinion can be a considerable driving force for building code revisions and improvements, as it has been for climate change policies for the past decade[12]. In light of our industry's impact on the environment, it has become clear that we MUST build using more sustainable materials. This article aims to determine the perceived barriers to tall wood construction to allow the building industry to develop strategies and overcome these barriers, and pave the way for constructing future high rise buildings with wood as the primary structural material.

2.0 RESEARCH OBJECTIVES AND METHODOLOGY

The aim of this research was to first distinguish if there are barriers as a result of the public's perception of engineered wood and, if so, to identify the greatest of these barriers. With this data, the building industry can develop tools to overcome these perceptual barriers, because, at this point, the barriers are just perceived, not actual, and the growing number of built tall wood projects stand as testaments that wood is a feasible structural material.

This survey was conducted through SurveyMonkey, an online cloud-based survey development company, from February 12, 2015 through February 16, 2015. It was open to all participants (ages 18-100) regardless of background, ethnicity, gender, income level, geographic area, etc. In addition to the data collected through the administered survey, SurveyMonkey provided supplementary information for each survey participant as part of their user profile. This information included age, gender, U.S. region, household income, and device type.

2.1. Survey Objectives

There were four primary objectives to this survey. The first was to gauge participant's familiarity with engineered wood products, the second objective was to identify the barriers of perception, and the third objective was to distinguish which of these barriers were the greatest. And finally, the fourth objective was to cross reference data from the various data sets (age, gender, region, income, and industry) to find correlations and decipher trends in the data.

2.2. Pilot Survey

Once the survey was drafted, a small pilot group was recruited to test the legibility and viability of the ques-

tions to be sure that the information being extracted was worthwhile and that the questions did not bias the survey takers towards a particular answer. The pilot group consisted of six respondents, three men and three women, who identified their industries as *Construction, Machinery and Homes* (1); *Entertainment & Leisure* (1); and *Health Care & Pharmaceuticals* (4). Pilot survey participants provided several points of compelling feedback, outlined here, that were considered and incorporated into the final survey.

Negative
Respondents had mixed opinions on the negative nature of the questions. One pilot respondent noted, "... the wording suggests that all of the barriers are actual problems – not just perceived un-validated problems," while another observed that the survey "swings to the negative side a bit but didn't find it too negative." However, the negative nature of the barrier statements must be considered since the results may be skewed by respondent's tendency to agree with statements without considering carefully, particularly with negative statements[13].

Personalize
Respondents felt the survey questions should be more personal, one suggested, "...rather than what is the general perception I wonder if you should be asking personal views... I would form your check box questions as more personal... I would ask some questions with the check boxes that are like 'would you live/work in a tall wood building?" As a result, a more personal barrier statement was added to the survey – "I would not live in a tall wood building" – written negatively to match the negative nature of the other barrier statements.

Definition
Respondents requested that definitions for Engineered Wood and Tall Wood Buildings be made available, and these were inserted. Additionally, examples of both Engineered Wood and Tall Wood Buildings were added to the survey to provide clarification and references to the participants.

Categories
Many of the pilot respondents felt that they did not fit well into any of the presented industry categories, thus an additional *Design* category option was provided for the Industries classification question.

Comments
A respondent commented that, "You are designing this for the general public and generally, people will be fine with doing the little check boxes, but when it comes to elaborating, you're going to get very few responses unless they feel passionate about the subject." Comment boxes were added to each question so that participants could provide additional information if they wished.

2.3. Administered Survey

Introduction
The survey began with the following introduction to help give the participants a sense of what this survey was trying to achieve:

This survey is made possible by a Perkins+Will Innovation Incubator micro-grant. The purpose of this survey is to gauge the market perception of tall wood buildings. A tall wood building is defined as a structure consisting primarily of mass timber of five stories or more.

Comment boxes have been provided under certain questions if you wish to elaborate on responses, but this is not required. We anticipate this online survey will require approximately 3 minutes to complete.

At Perkins+Will, we've created a practice where design, technology and research converge to create places that improve how we live and work. Our Innovation Incubator program fosters an invigorating culture of innovation by supporting small, focused research projects proposed by staff members through micro-grants of money and time.

In recent years, a number of wood buildings have been constructed over seven stories, including the 10-story Forte building in Melbourne, Australia and the 14-story Treet building in Bergen, Norway, with a few others under design that achieve 30 stories in height.

Thank you in advance for your contribution!

Industry
Following the introduction, question one (Q1) of the survey asked respondents to identify their principal industry (Figure 1). Respondents who chose the *Other* industry were asked to specify their responses in the comment box. Some of those that identified themselves as *Other* were clearly part of one of the industries listed thus were recategorized to the appropriate industry. For example, respondents who identified themselves as a nurse or a mental health specialist in the *Other* industry comment box were recategorized as *Health Care & Pharmaceuticals*. Likewise, a graphic designer was recategorized as *Design*. Respondents who noted they were retired from or studying in an industry were cat-

egorized under their correlated industries. For example, a retired teacher was recategorized with *Education* and a nursing student was recategorized with *Health Care & Pharmaceuticals*. Participants who noted they were retired, a student, or unemployed without specifying their industry remained in the *Other* category. Fifty-seven respondents were recategorized from the *Other* industry group in this manner.

We are very interested in collecting information on your industry so we can track trends in opinions on the barriers of tall wood by market sector.

***1. Please identify your principal industry: (select one)**

- ◯ Advertising & Marketing
- ◯ Agriculture
- ◯ Airlines & Aerospace (including Defense)
- ◯ Automotive
- ◯ Business Support & Logistics
- ◯ Construction, Machinery and Homes
- ◯ Design
- ◯ Education
- ◯ Entertainment & Leisure
- ◯ Finance & Financial Services
- ◯ Food & Beverage
- ◯ Government
- ◯ Health Care & Pharmaceuticals
- ◯ Insurance
- ◯ Manufacturing
- ◯ Nonprofit
- ◯ Retail & Consumer Durables
- ◯ Real Estate
- ◯ Telecommunications, Technology, Internet & Electronics
- ◯ Utilities, Energy, and Extraction
- ◯ Other (please specify)

Figure 1: Q1 asked participants to identify their primary industry.

Familiarity

Question two (Q2) of the survey asked participants to gauge their level of familiarity with engineered wood products used for building structure (Figure 2). A definition for this material was provided along with examples of engineered wood products specifically used for building structure. Respondents were asked to rate their familiarity on a scale from *Not at all familiar* through varying degrees of familiarity up to *Very familiar*.

We would like to gauge your familiarity with engineered wood products used for building structure.

According to Wikipedia, engineered wood, also called composite wood, man-made wood, or manufactured board; includes a range of derivative wood products which are manufactured by binding or fixing the strands, particles, fibers, or veneers or boards of wood, together with adhesives, or other methods of fixation to form composite materials.

Examples of engineered wood used for building structure include Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), Glued Laminated Timber (Glulam), and Nail Laminated Timber (NLT), among others.

***2. How familiar are you with engineered wood products used for structure in buildings: (select one)**

Not at all familiar	Somewhat unfamiliar	Somewhat familiar	Familiar	Very familiar
○	○	○	○	○

Figure 2: Q2 asked participants to gauge their familiarity with engineered wood products.

Barriers

Popular barrier statements were chosen for question three (Q3) of the survey to gauge respondent's degree of agreement with barriers (Figure 3). The participants were asked to rate their level of agreement from *Strongly Disagree* through decreasing levels of disagreement to *Neutral / Not Sure* through increasing levels of agreement to *Strongly Agree*. A comment box was provided.

***3. To what extent do you agree or disagree with these statements: (select one per row)**

	Strongly Disagree	Disagree	Somewhat Disagree	Neutral / Not Sure	Somewhat Agree	Agree	Strongly Agree
Wood is flammable; the building will burn quickly.	○	○	○	○	○	○	○
Termites will eat a wood building.	○	○	○	○	○	○	○
The strength of wood cannot compare to steel and concrete.	○	○	○	○	○	○	○
Building more of our tall buildings with wood will deplete our forests.	○	○	○	○	○	○	○
A wood building will cost more than steel and concrete.	○	○	○	○	○	○	○
Wood is less durable than steel and concrete.	○	○	○	○	○	○	○
Wood delivers poor acoustical performance.	○	○	○	○	○	○	○
Wood is vulnerable to moisture; it will rot.	○	○	○	○	○	○	○
Insurance is more expensive for a tall wood building.	○	○	○	○	○	○	○
Building with wood is more time consuming.	○	○	○	○	○	○	○
Wood buildings are aesthetically unappealing.	○	○	○	○	○	○	○
I would not live in a tall wood building.	○	○	○	○	○	○	○

Comments

Figure 3: Q3 asked participants to rate their level of agreement with barrier statements.

Greatest Barriers

Finally, in question four (Q4) of the survey, respondents were asked to choose the three greatest barriers from the list of statements (Figure 4). An additional statement - *I do not believe any of these are barriers* - was included as an option. This question asked participants to select three statements, however only one selection was required to complete the question. A comment box was provided for respondents to elaborate on their answers.

***4. Of the statements reviewed in the previous question, identify the three greatest barriers to tall wood construction: (select three)**

- ☐ Wood is flammable; the building will burn quickly.
- ☐ Termites will eat a wood building.
- ☐ The strength of wood cannot compare to steel and concrete.
- ☐ Building more of our tall buildings with wood will deplete our forests.
- ☐ A wood building will cost more than steel and concrete.
- ☐ Wood is less durable than steel and concrete.
- ☐ Wood delivers poor acoustical performance.
- ☐ Wood is vulnerable to moisture; it will rot.
- ☐ Insurance is more expensive for a tall wood building.
- ☐ Building with wood is more time consuming.
- ☐ Wood buildings are aesthetically unappealing.
- ☐ I do not believe any of these are barriers.

Comments

Figure 4: Q4 asked participants to identify the greatest barriers to tall wood construction.

3.0 RESULTS

Five hundred seventy-two responses were collected through this survey. Five hundred eighteen surveys were complete. Only data from the completed surveys was included in this research.

Median time to complete the survey was 2 minutes and 56.5 seconds.

Population Surveyed

One of the primary goals of the survey was to collect data from a diverse cross section of the United States population to ensure the results were not biased towards one particular group. The respondent population was sufficiently diverse and reflected a nearly perfect cross section of the U.S. population in terms of gender (Figure 5a)[14], age (Figure 5b)[14], region (Figure 5c)[15], and income (Figure 5d)[16]. The cross section for industries (Figure 5e) could not be determined since the industry categories and process for categorization were inconsistent between the U.S. Census Bureau and survey.

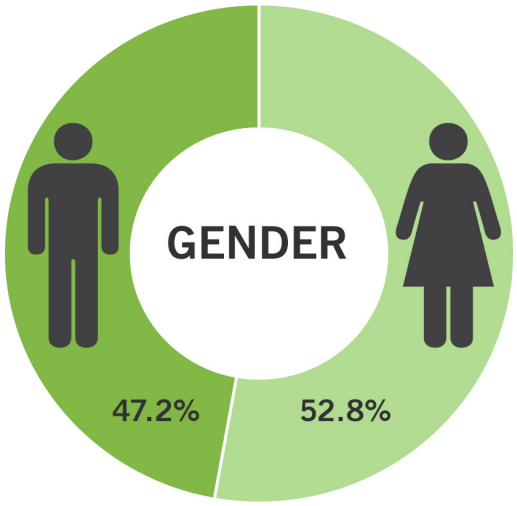


Figure 5a: Respondent population by gender.

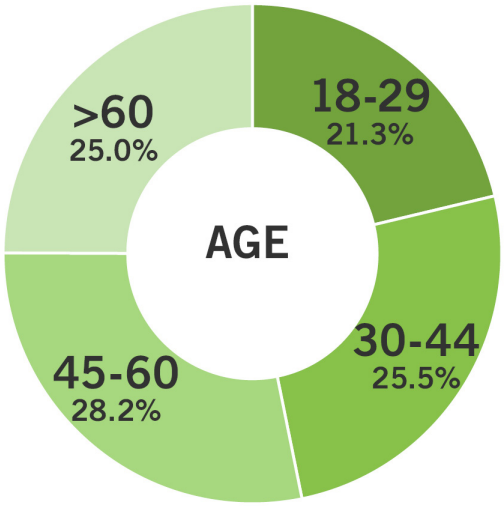


Figure 5b: Respondent population by age.

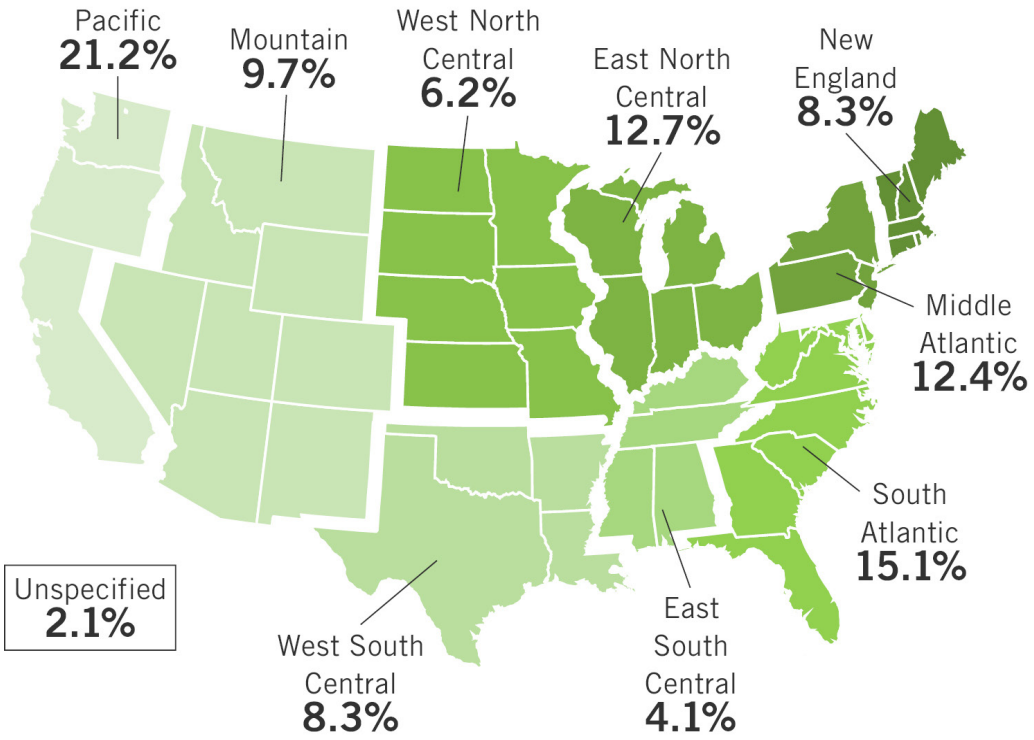


Figure 5c: Respondent population by region.

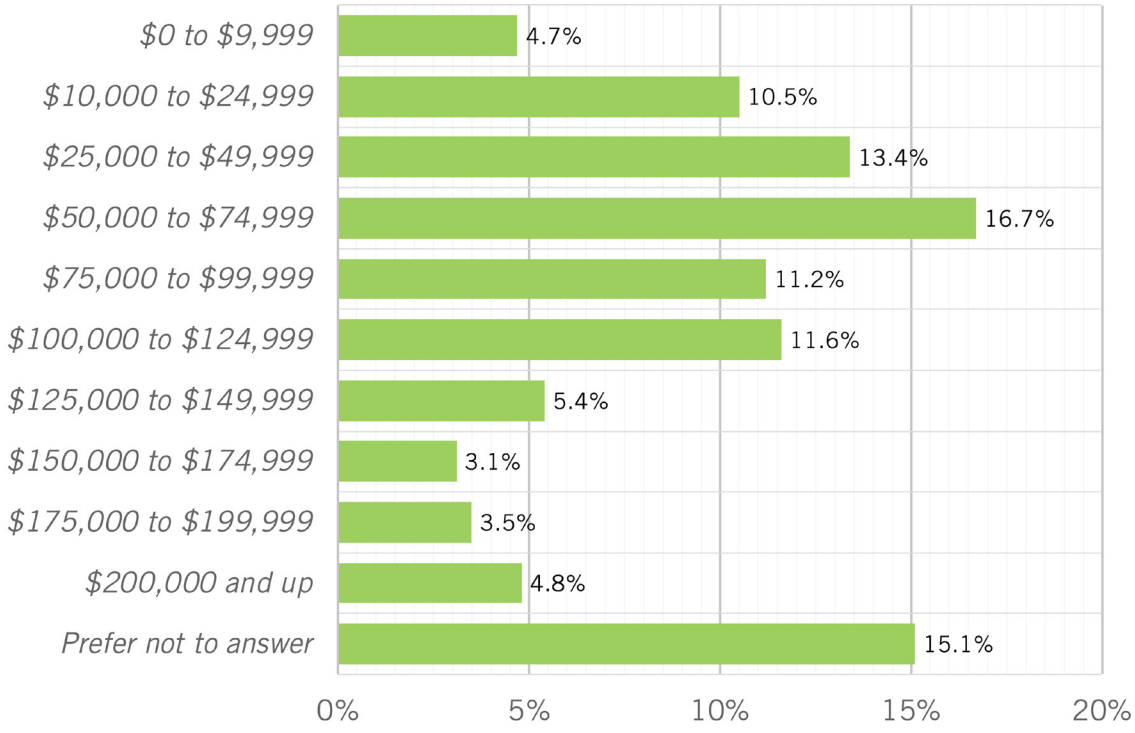


Figure 5d: Respondent population by income.

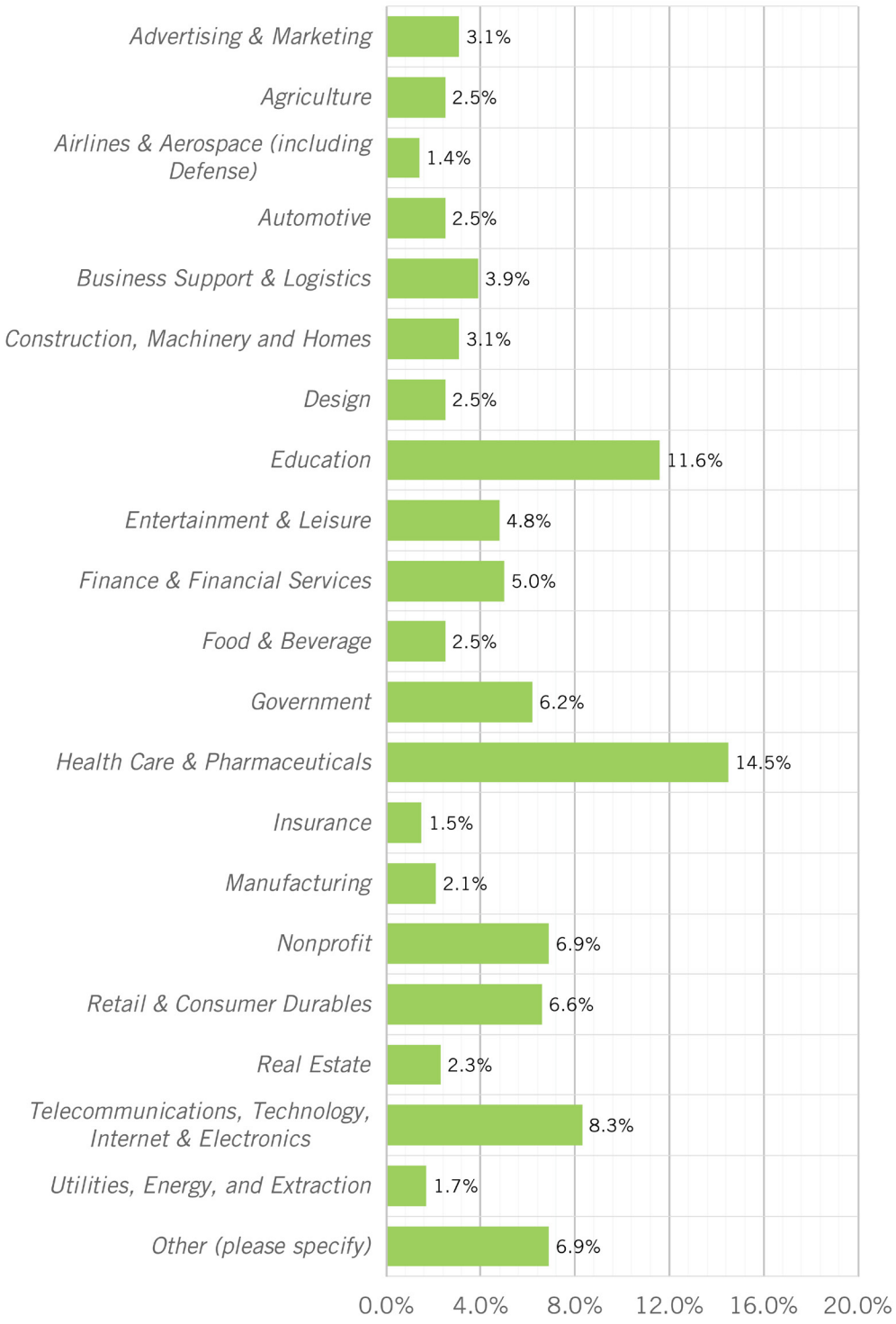


Figure 5e: Respondent population by industry.

Baseline for Familiarity

Nearly half of respondents (45 percent) claimed no familiarity at all, while merely 4 percent of respondents asserted that they were *Very Familiar* with engineered wood products used in building structures (Figure 6). Another 17 percent noted that they were *Somewhat Unfamiliar*, 26 percent professed that they were *Somewhat Familiar*, and 8 percent stated that they were *Familiar* with engineered wood products. Therefore, only one third of survey takers were familiar to some degree with engineered wood products.

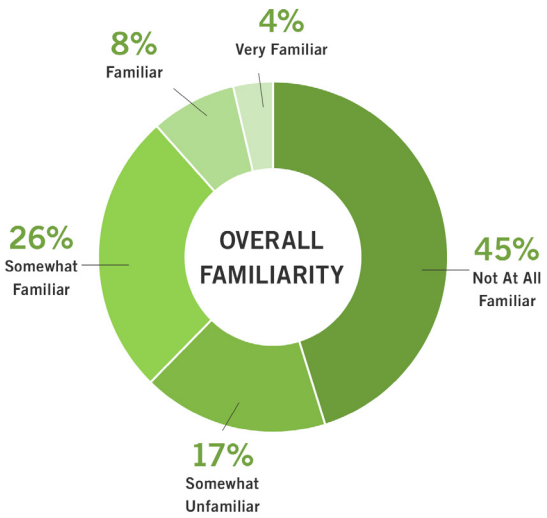


Figure 6: Baseline familiarity with engineered wood products.

Baseline for Degree of Perception

Overall, survey respondents rated P1-Flammability, P2-Termites, and P6-Durability highly as barriers, followed by P3-Strength, P4-Deforestation, and P8-Moisture (Figure 7). Graphs with peaks on the right side indicated strong agreement with the perception statement, while peaks on the left indicated strong disagreement with the perception statement. P5-Cost, P7-Acoustics, P9-Insurance, and P10-Time received a large number of *Neutral/Not Sure* responses as indicated by the sharp spike in the middle of the graph.

Reassuringly, P11-Aesthetics received a high level of disagreement making it definitively not a barrier and supporting the plethora of research[17] that postulates that people who work, learn and live in spaces with exposed wood are healthier, happier and more productive. As for living in a tall wood building, 50 percent of respondents say they would, 30 percent were unsure, and only 20 percent would not live in a tall wood building.

Figure 7: Baseline perception for each barrier statement.

Baseline for Greatest Barriers

Perhaps unsurprising, P1-Flammability was identified as the greatest barrier, with P3-Strength and P4-Deforestation rounding out the top three (Figure 8). P10-Time, P7-Acoustics and P11-Aesthetics were among the least great barriers. Encouragingly, 13 percent of the respondents believed that none of these statements were barriers.

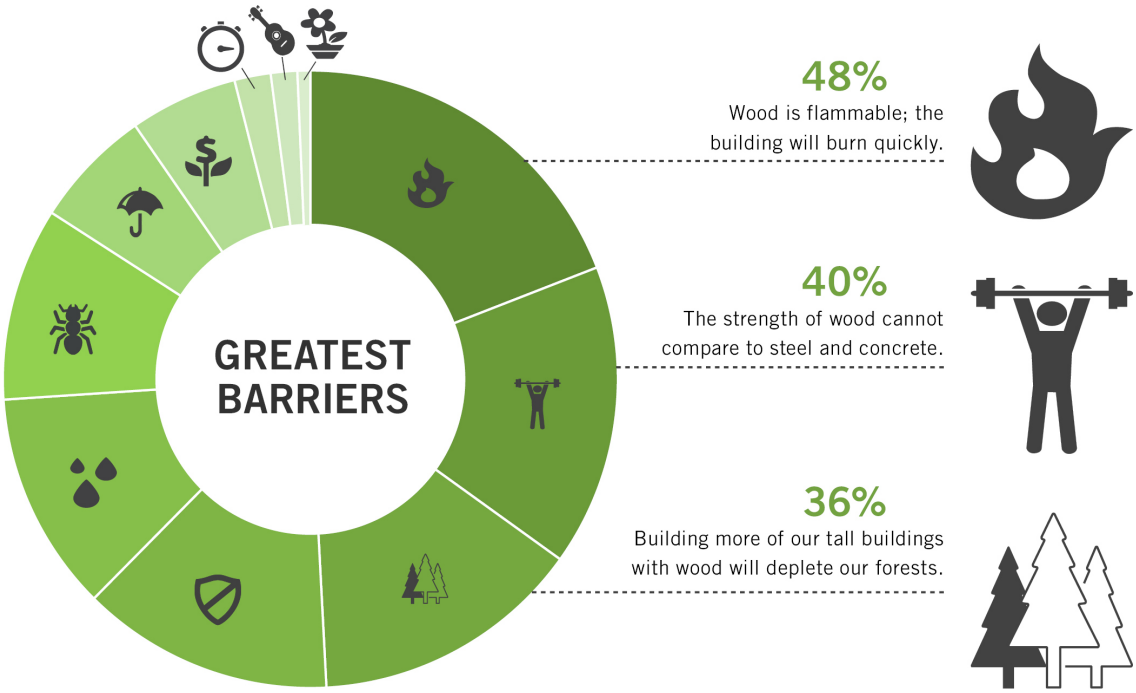


Figure 8: Barrier perception statements ordered from greatest to least.

4.0. ANALYSIS

Outcome Categories

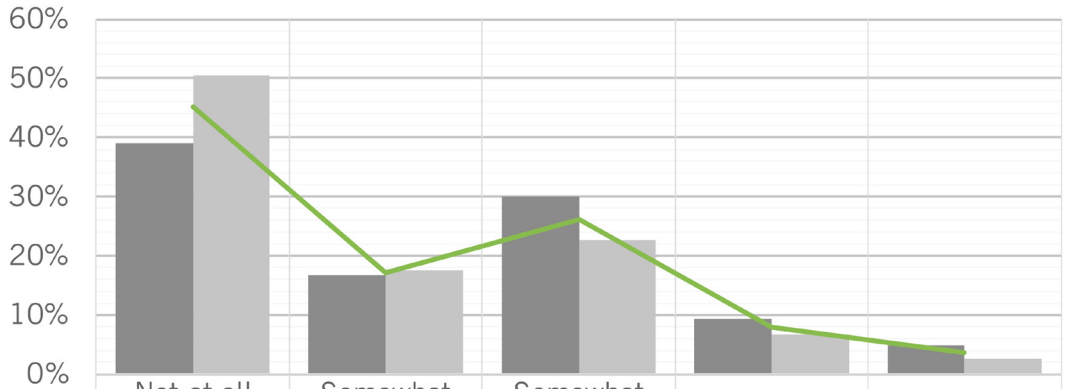
The baselines for familiarity, degree of perception, and greatest barriers have been established in the previous section, the following pages categorize the data by gender, age, region, income, and industry. This section ends with a comparison of familiarity to degrees of perception. The outcomes from these categories have been cross-tabulated with the baseline data to reveal trends and correlations.

By Gender

Surveyed men (44 percent) conveyed a greater degree of familiarity with engineered wood products used for building structure than women (32 percent) (Figure 9). Women agreed to a higher degree than men with three perceptions in particular, P1-Flammability (55 percent men / 67 percent women), P2-Termites (55 percent men / 63 percent women) and P4-Deforestation (49 percent men / 65 percent women) indicating that women believe these are barriers to a higher degree than men do. Women were more likely to agree that wood is aesthetically appealing (P11) (74 percent men / 82 percent women) and three percent more women would live in a tall wood building (P12) than men, while 6 percent more men thought none of the presented perception statements were barriers to building tall wood buildings with engineered wood products.

Men and women agreed that P1-Flammability was the greatest barrier in constructing tall wood buildings, and both were concerned with the strength (P3) of wood to differing degrees (Figure 10). However, men were additionally concerned with the durability (P6) of wood, while women were concerned more over the depletion of forests (P4).

This data also revealed that female respondents only made up 7 percent of the industry that expressed the greatest familiarity with engineered wood products – *Construction, Machinery & Homes*. However, women made up more than half of the three industries that followed in familiarity – *Agriculture* (54 percent), *Design* (69 percent), and *Real Estate* (58 percent). Women also made up more than half of the industry that expressed the least amount of familiarity – *Nonprofit* (55 percent).



	Not at all familiar	Somewhat unfamiliar	Somewhat familiar	Familiar	Very familiar
Male	39%	17%	30%	9%	5%
Female	51%	18%	23%	7%	3%
Baseline	45%	17%	26%	8%	4%

Figure 9: Familiarity by gender.

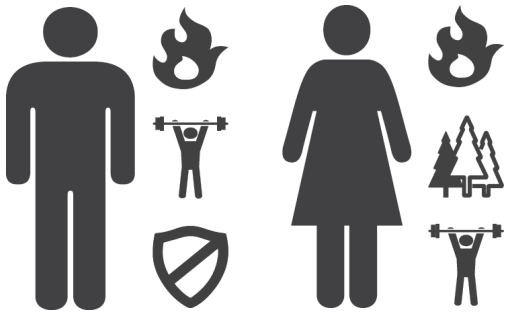


Figure 10: Greatest barriers by gender.

By Age

The level of familiarity with engineered wood products used for building structure increased with the age of the participants (Figure 11). The youngest group of participants had the highest level of unfamiliarity (62 percent), while the eldest group claimed the highest level of familiarity (47 percent) with these products. Furthermore, respondents from the *18-29* group were more likely to choose *Neutral / Not Sure* for barrier statements than any other age group. In contrast, the eldest group of participants were more likely to disagree with the barrier statements, which suggests that experienced individuals are more familiar with engineered wood products and thus have a better understanding of their properties.

The youngest group expressed greater concern for deforestation (P4) than the older groups (61 percent *18-29* / 54 percent *>60*). Respondents from the eldest group felt wood was more aesthetically pleasing (P11) than other age groups (82 percent *>60* / 73 percent *18-29*) and were more likely to live in a tall wood building (P12) than younger respondents (50 percent *>60* / 44 percent *18-29*).

To some degree, all age groups felt that P1-Flammability was one of the greatest barriers (Figure 12). The data also reflects concern for material strength (P3), durability (P6) and deforestation (P4) from all groups. Despite a certain level of familiarity, 12 percent of each of the youngest three age groups and 15 percent of the eldest group felt that none of these statements were barriers to the construction of tall wood buildings. This implies that public awareness and education campaigns are one way to disseminate knowledge of engineered wood products to increase familiarity and overcome misconceptions.

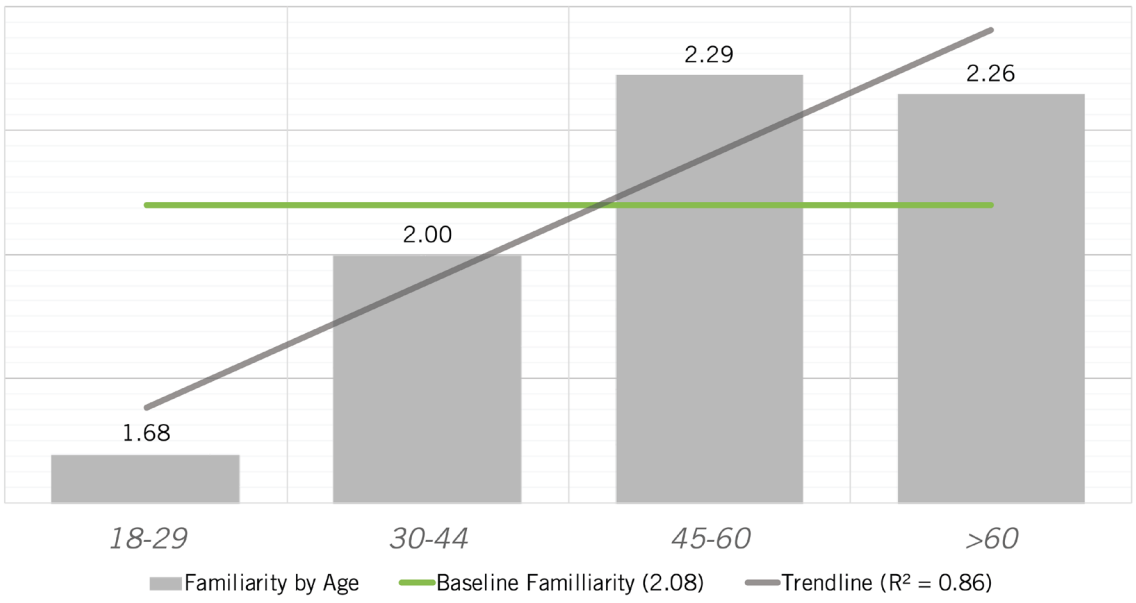


Figure 11: Familiarity by age with trendline (based on weighted average out of 5.00).

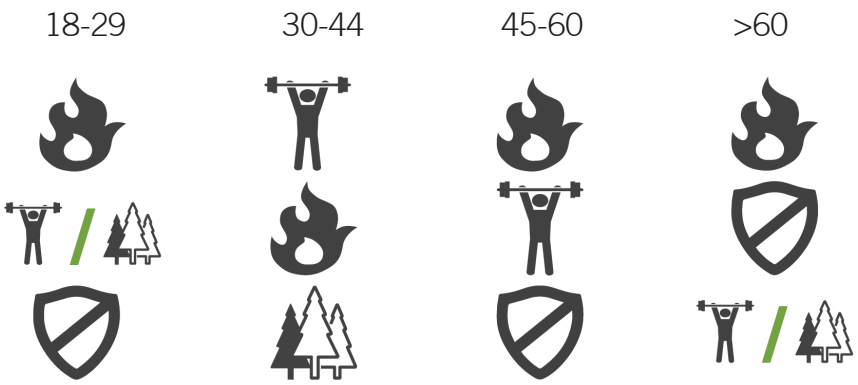


Figure 12: Greatest barriers by age.

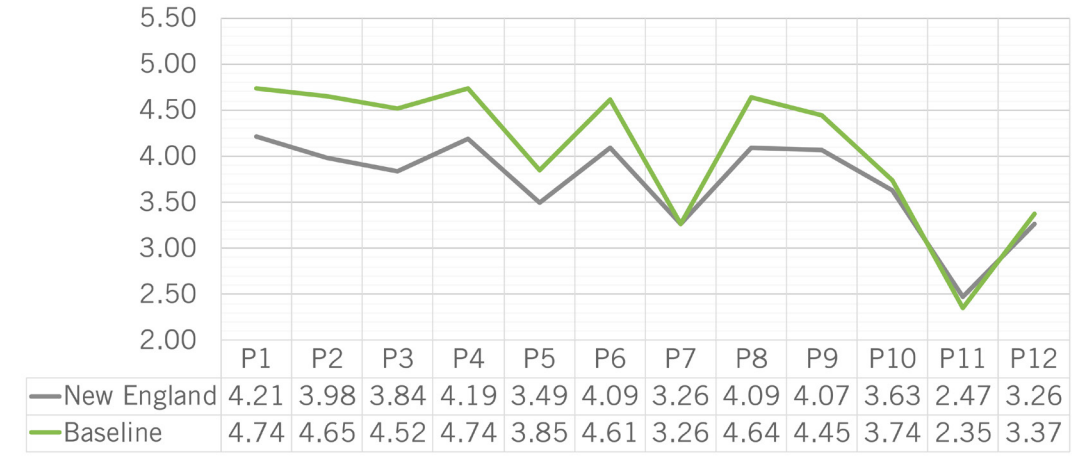
By Region

The data set on regions is likely only large enough to provide some speculations; however, it did provide some insight into how the country's geographical make-up and regional resources might influence our perceptions and familiarity. Forty-seven percent of *West North Central* respondents claimed some level of familiarity with engineered wood products, the most from any region. This data is a bit surprising since the region is not considered a hub for engineered wood manufactory, unlike the *Pacific* region, which boasts over a half dozen manufacturers and yet, only 39 percent claimed some level of familiarity, only one percent more than the survey average. The *East South Central* and *Middle Atlantic* regions were the most unfamiliar with only a 24 percent and a 28 percent degree of familiarity, respectively. Also of note, the *Mountain* region (42 percent) and *New England* region (40 percent) claimed above average familiarity with these products.

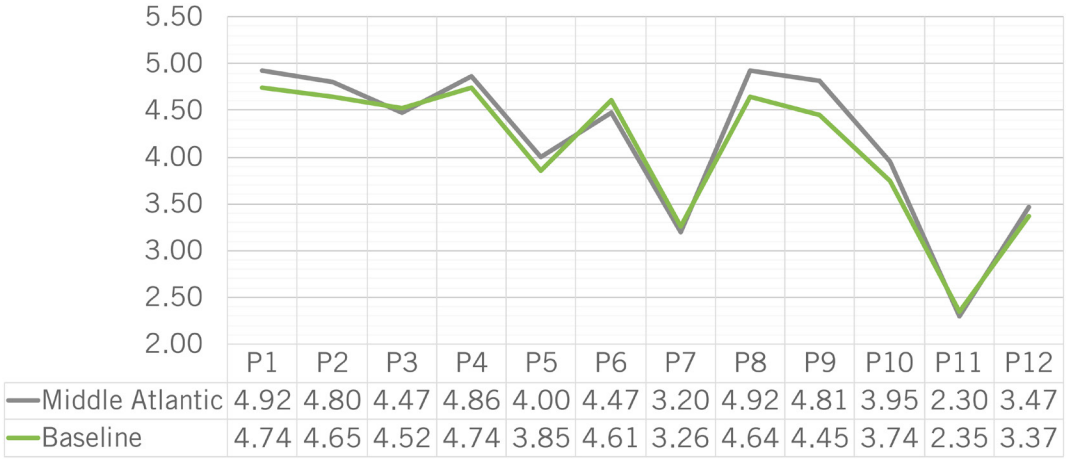
Overall, the *New England* and *East North Central* regions disagreed to the greatest degree with the negative barrier statements, meaning these respondents did not consider the statements to be barriers, while the *Middle Atlantic* region and *South Atlantic* region agreed the most with the perceptions (Figure 13). More than half of participants from the *East North Central, East South Central, Mountain, Pacific,* and *West South Central* regions would live in a tall wood building (P12). However, one quarter of participants from the *Middle Atlantic* and *West North Central* regions would not live in a tall wood building (P12).

As with the other data sets, P1-Flammability was identified as one of the greatest barriers for all regions (Figure 14). The regions similarly identified P3-Strength and P4-Deforestation as top concerns. P6-Durability and P8-Moisture also made an appearance in the top three for the *Middle Atlantic* and *Mountain* regions.

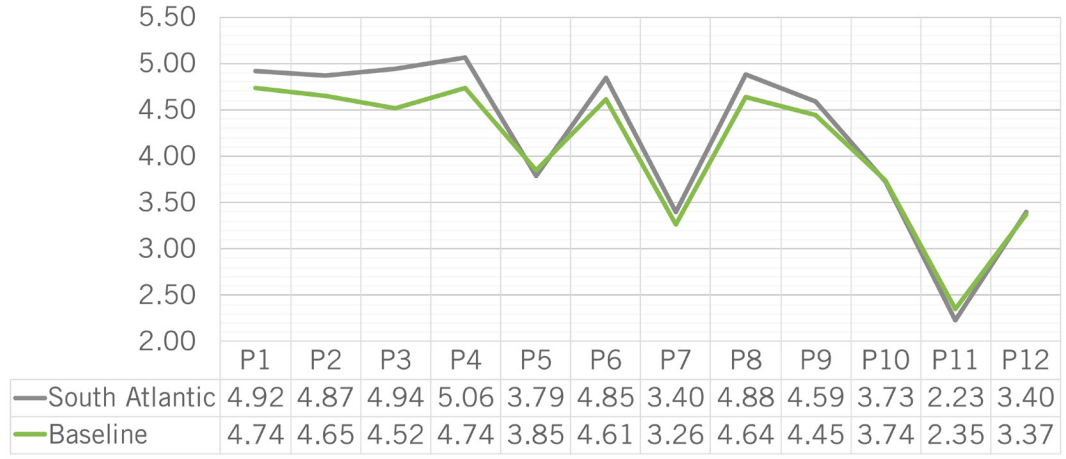
The *Unspecified* regions group, which made up only 2 percent of respondents, tended to choose *Neutral / Not Sure* more often than other region groups and also expressed a high level of familiarity (45 percent) with engineered wood products. An astounding 36 percent from this group would not live in a tall wood building.



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
New England	4.21	3.98	3.84	4.19	3.49	4.09	3.26	4.09	4.07	3.63	2.47	3.26
Baseline	4.74	4.65	4.52	4.74	3.85	4.61	3.26	4.64	4.45	3.74	2.35	3.37



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Middle Atlantic	4.92	4.80	4.47	4.86	4.00	4.47	3.20	4.92	4.81	3.95	2.30	3.47
Baseline	4.74	4.65	4.52	4.74	3.85	4.61	3.26	4.64	4.45	3.74	2.35	3.37



	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
South Atlantic	4.92	4.87	4.94	5.06	3.79	4.85	3.40	4.88	4.59	3.73	2.23	3.40
Baseline	4.74	4.65	4.52	4.74	3.85	4.61	3.26	4.64	4.45	3.74	2.35	3.37

Figure 13: Level of agreement with barrier statements for *New England, Middle Atlantic,* and *South Atlantic* regions (based on weighted average out of 7.00).

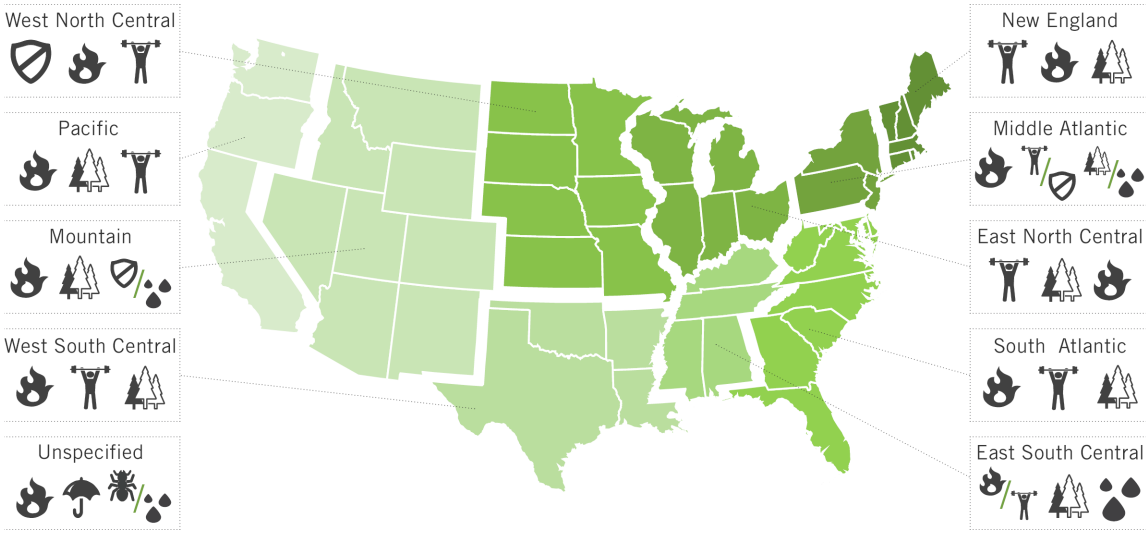


Figure 14: Greatest barriers by region.

By Industry

As with the previous section on regions, the industry data set is not large enough to reach any specific conclusions, but the data exposed some interesting trends. *Agriculture* (77 percent), *Construction, Machinery & Homes* (69 percent), and *Design* (69 percent) indicated the most familiarity with engineered wood products (Figure 15). Participants from the *Other* (22 percent) and *Nonprofit* (22 percent) industries revealed the least amount of familiarity.

The industries that denoted a greater degree of disagreement overall with barrier statements were *Advertising & Marketing; Agriculture; Airlines & Aerospace; Construction, Machinery & Homes; Manufacturing;* and *Nonprofit*. The industries that exhibited a higher level of agreement with the statements were *Entertainment & Leisure; Real Estate;* and *Other*.

The biggest surprise for this set of data is that the barrier which had been prevalent in all the previous data sets – P1-Flammability - was not indicated as the greatest for all industries (Figure 16). Another item of note is the number of ties for first, second and third greatest barrier for many of the industries. This is likely due to the small number of participants in some industries, or it is possible that some industries considered most of the statements to be equal barrier issues. This is particularly relevant for the *Design* industry, which has the greatest tie for third with five barriers. Other industries with an above average amount of ties include *Airlines & Aerospace; Entertainment & Leisure; Real Estate;* and *Utilities, Energy & Extraction*.

Predictably, the *Insurance* industry was one of the few to indicate that cost of insurance (P9) is one of the greatest barriers with 50 percent of industry participants identifying it as the second greatest barrier. Thirty-eight percent of *Advertising & Marketing* respondents indicated that they did not believe these were barriers, followed by *Automotive* with 31 percent and *Airlines & Aerospace* with 29 percent.

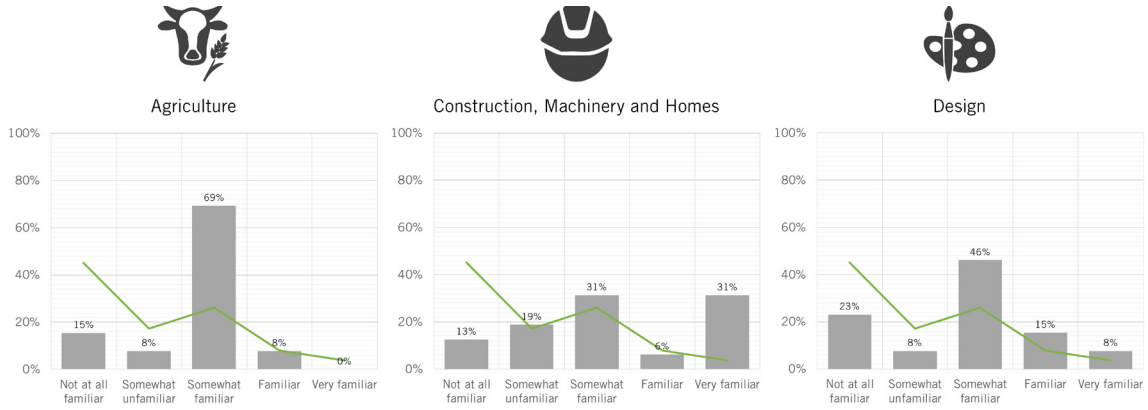


Figure 15: Level of familiarity for *Agriculture; Construction, Machinery and Homes*; and *Design* industries.

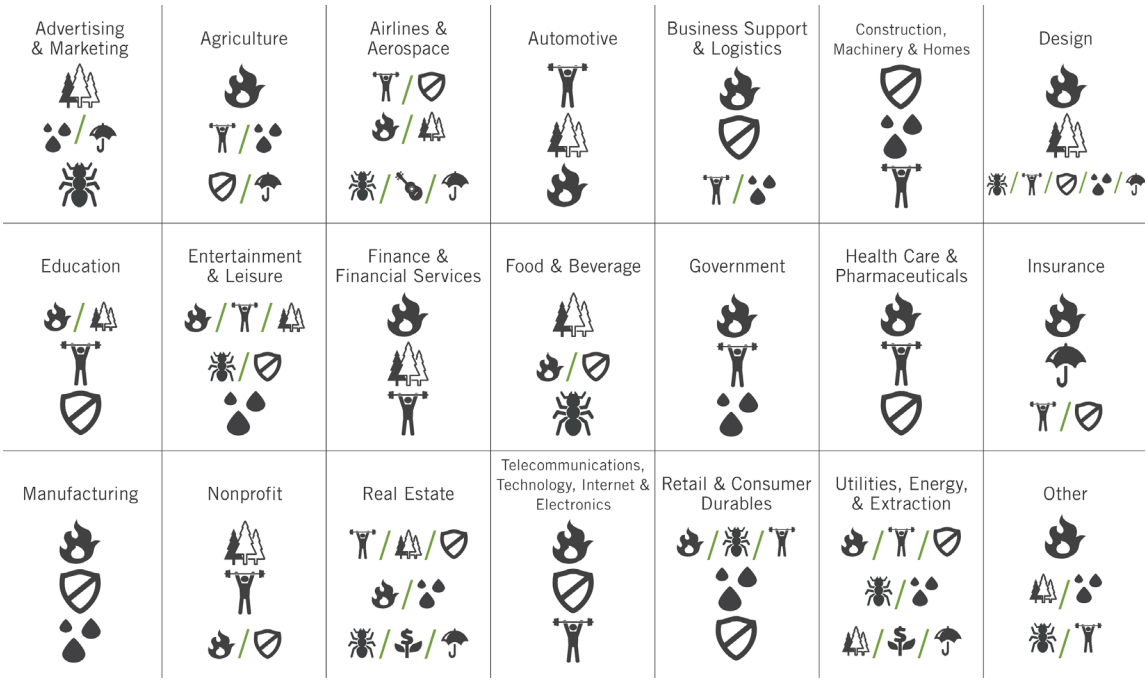


Figure 16: Greatest barriers by industry.

By Income

This income data set had some interesting and unexpected outcomes. The trendline of the familiarity graph revealed that respondents with greater household incomes had greater levels of familiarity with engineered wood products, with a few exceptions. Respondents in the *$10k-24K* (39 percent) range expressed a greater level of familiarity than expected, while those in the *$150k-174K* (31 percent) and *>$200k* (24 percent) ranges conveyed a lower level of familiarity than anticipated (Figure 17). The income ranges that disclosed the greatest degree of disagreement overall with the barrier statements were *$75K-99K, $150-174K,* and *$175K-199K*, while the *$10K-24K* and *$25K-49K* ranges conveyed a higher level of agreement overall. There were a significant number of *Prefer Not to Answer* respondents (15.1 percent), which were excluded from graphs with trendlines.

As with the other data sets, most of the income ranges identified P1-Flammability as one of the greatest barriers to building tall with wood with the exception of the *$10K-24K* range, who did not even identify P1 – Flammability as one of the top three barriers, instead identifying P8- Moisture, P4- Deforestation, and P2-Termites as their greatest. The *$25k-49k* and *$175K-199K* ranges also identified other barrier statements as greatest; P3-Strength and P8-Moisture, respectively.

The *$175k-199k* income group indicated the greatest level of disagreement with the statement "I would not live in a tall wood building." This group also expressed the highest familiarity with wood, which is no coincidence, as the next section will discuss (Figure 18).

Twenty-two percent of the *$100k-124k* income range indicated that they did not believe any of these were barriers – the most of any group, followed by *$10k-24k* with 19 percent.

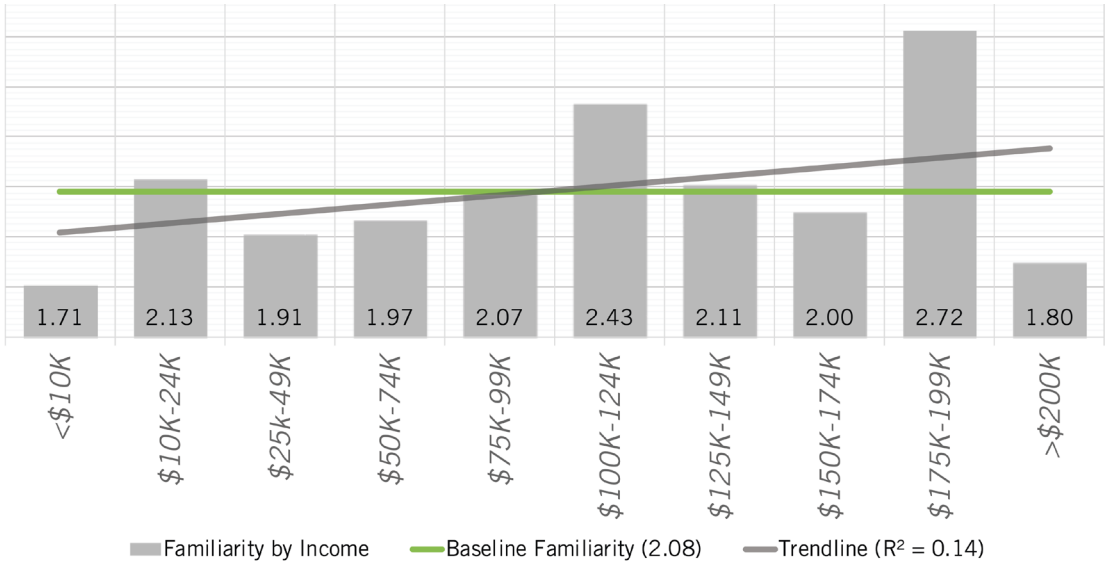


Figure 17: Familiarity by income with trendline (based on weighted average out of 5.00).

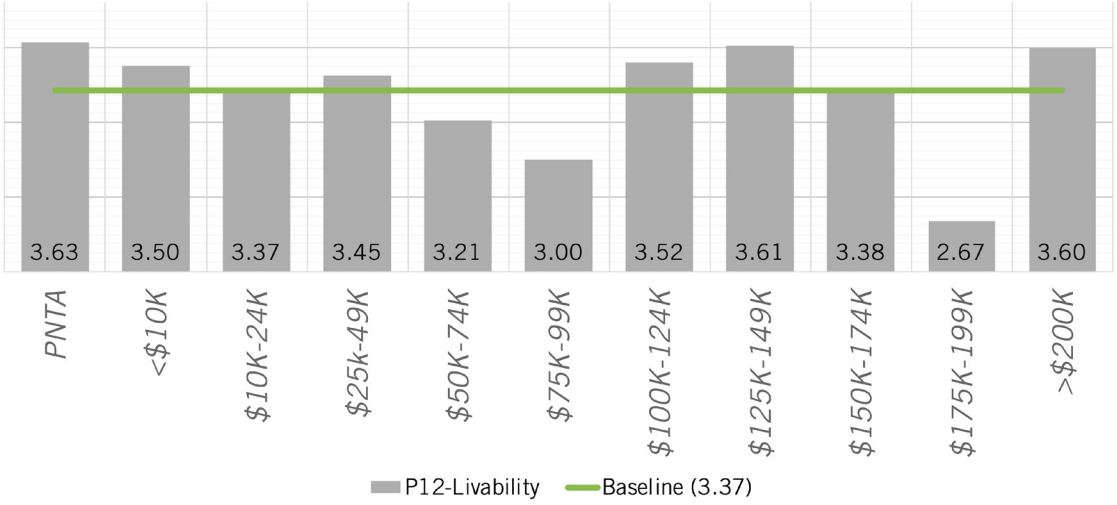
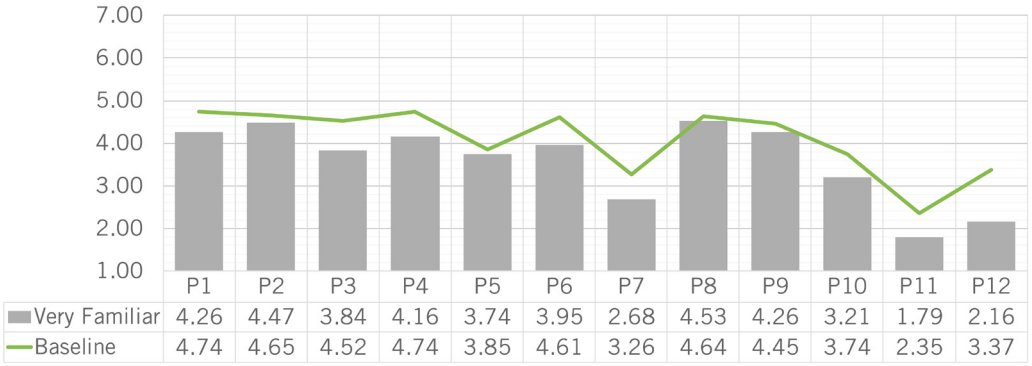


Figure 18: Degree of perception by income of P12-Livability (based on weighted average out of 5.00).

By Familiarity

Respondents who indicated the greatest level of familiarity with engineered wood products had the lowest levels of agreement with the negative barrier statements. In other words, those who were most familiar with wood were the least concerned with barriers (Figure 19). Additionally, these respondents pointed to different and, what engineered wood experts consider to be more realistic, barriers as the greatest concern for building with tall wood including P8-Moisture, P9-Insurance, P5-Cost, and P6-Durability while those less familiar identified P1-Flammability as the greatest.

An encouraging 37 percent of respondents from the *Very Familiar* group did not believe any of these statements were barriers, while only 9 percent of the *Not At All Familiar* group believed the same to be true. The *Very Familiar* (2.16) group are the most likely to live in tall wood buildings while the *Not At All Familiar* (3.57) group is the least likely.



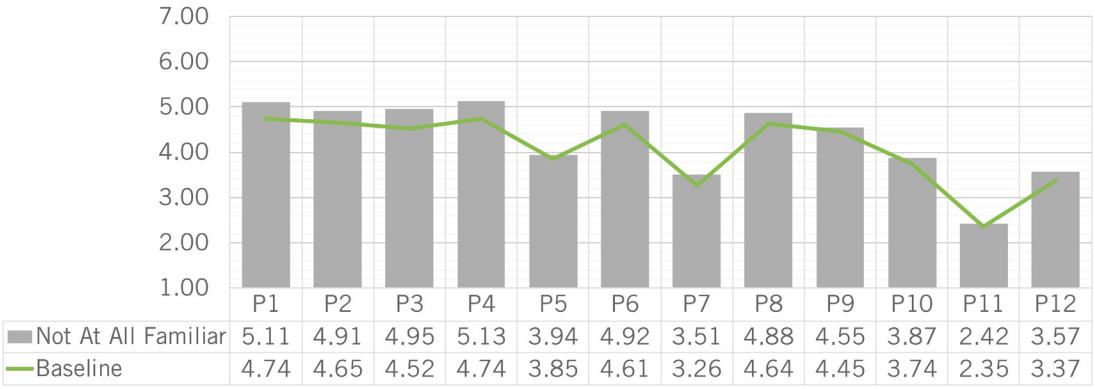


Figure 19: Level of Familiarity cross referenced with Degree of Perception for *Very Familiar* and *Not At All Familiar* groups (based on weighted average out of 7.00).

5.0 CONCLUSION

The survey validated that perception barriers are diminished with experience and knowledge. This data indicates earlier assumptions were correct – by educating the public on the attributes of engineered wood products, perceptual barriers can be overcome. Even considering the negative nature of the statements and the tendency for respondent acquiescence, the degree of agreement with the statements may have been lower, but the results would likely have been similar.

Many of the negative barrier statements are false. For example, P1-Flammability is not a barrier to building tall with wood since timber chars when it burns and insolates itself. A properly designed engineered wood building with a sacrificial charring layer would safely withstand a fire event. However, if the public perceives an engineered wood building to be flammable, the marketability and lease rate may be negatively affected. People are unlikely to live or work in places they identify as dangerous, which is why it is so important to educate the public on the true properties of this material.

This research was meant to be just one of many steps in identifying the barriers created by the perceptions of tall wood buildings. The next step needs to zoom in on our industry by first identifying stakeholders, surveying those stakeholders, and then following up with interviews so that we may refine these barriers. Stakeholders might include contractors, architects/designers, engineers, owners/clients, developers, potential buyers/renters, users, code officials, and authorities having jurisdiction.

To tackle public perception barriers, our industry only need market engineered wood products and educate the people on their properties and benefits. As the public's knowledge of these products grow, so will the demand for tall wood buildings.

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REFERENCES

[1] United Nations Department of Economic and Social Affairs, (2015). "World Population Prospects: The 2015 Revision, Key Findings and Advance Tables", Report, Retrieved on 04/2016 from http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf.

[2] United Nations, Department of Economic and Social Affairs, Population Division, (2014). "World Urbanization Prospects: The 2014 Revision, Highlights", Report, Retrieved on 02/2016 from http://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf.

[3] International Energy Agency, (2013). "Transition to Sustainable Buildings", Report, Retrieved on 04/2016 from http://www.iea.org/Textbase/npsum/building-2013SUM.pdf.

[4] Dovetail Partners, Inc., (2015). "Building with Wood = Proactive Climate Protection", Report, Retrieved on 04/2016 from http://www.dovetailinc.org/report_pdfs/2015/building_with_wood.pdf.

[5] reThink Wood, (2015). "Summary Report: Survey of International Tall Wood Buildings", Report, Retrieved on 04/2016 from http://www.rethinkwood.com/sites/default/files/wood-resourse-pdf/Survey-of-International-Tall-Wood-Buildings.pdf.

[6] U.S. Tall Wood Building Prize Competition, (2015). "Building Taller with Wood", Report, Retrieved on 04/2016 from https://tallwoodbuildingcompetition.org/wp-content/uploads/2015/09/Building-Tall-With-Wood-Backgrounder.docx.

[7] Michael Green Architecture, (2012). "The Case for Tall Wood", Report, Retrieved on 04/16 from http://mg-architecture.ca/wp-content/uploads/2016/01/publications-Tall-Wood.pdf.

[8] Skidmore, Owings & Merrill LLP, (2013). "Timber Tower Research Project", Report, Retrieved on 04/16 from http://www.som.com/FILE/20378/timber-tower-final-report-and-sketches.pdf.

[9] Skidmore, Owings & Merrill LLP, (2014). "Timber Tower Research Project: System Report #1", Report, Retrieved on 04/16 from http://www.som.com/FILE/22294/timber-report-gravity-system.pdf.

[10] Forestry Innovation Investment (2014). "Summary Report: Survey of International Tall Wood Buildings", Perkins+Will Research Journal, Vol. 06, No. 02, pp. 7-19.

[11] Holt, R. and Wardle, K., (2014). "Lessons from Tall Wood Buildings: What We Learned from Ten International Examples", Report, Retrieved on 04/16 from http://www.rethinkwood.com/sites/default/files/wood-resourse-pdf/Survey-of-International-Tall-Wood-Buildings.pdf.

[12] Hagen, B., (2015). Public Perception of Climate Change: Policy and Communication, New York, NY: Routledge.

[13] Colosi, R., (2008). "Negatively Worded Questions Cause Respondent Confusion", Report, Retrieved on 04/2016 from http://www.amstat.org/sections/srms/proceedings/y2005/files/jsm2005-000508.pdf.

[14] United States Census Bureau, Current Population Survey, (2012). "Age and Sex Composition of the United States: 2012", Table, Retrieved on 02/2016 from https://www.census.gov/population/age/data/files/2012/2012gender_table1.xlsx.

[15] United State Census Bureau, Current Estimates Data, (2015). "Annual Estimate of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2015", Table, Retrieved on 02/2016 from http://www.census.gov/popest/data/state/totals/2015/tables/NST-EST2015-01.xlsx.

[16] United States Census Bureau, Current Population Survey, (2014). "Selected Characteristics of Households, by Total Money Income in 2014, All Races", Table, Retrieved on 02/2016 from https://www.census.gov/hhes/www/cpstables/032015/hhinc/hinc01_1.xls.

[17] Planet Ark Environmental Foundation, Make It Wood, (2015). "Wood, Housing, Health, Humanity Report 2015", Report, Retrieved on 02/2016 from http://makeitwood.org/documents/doc-1253-wood--housing--health--humanity-report-2015-04-00-final.pdf.