

## Assessing the feasibility of structural timber construction in South Africa

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### ABSTRACT

This study assessed the feasibility of timber as a structural construction material in the South African construction industry by assessing the perspectives of industry stakeholders. Using an online survey, the study collected the views of 94 stakeholders. Respondents considered timber superior to brick, concrete, and steel in attributes such as ease of construction, speed of construction, and appearance. They considered timber similar in quality and durability to other materials but inferior in the local supply of materials and skillset. The study has also shown that negative perceptions of timber, the lack of skills and knowledge, and cost concerns are perceived barriers limiting timber adoption in South Africa. Recommendations for increased adoption of timber construction include the promotion of timber, pilot projects and training. This paper contributes to the expanding body of knowledge on timber and addresses the need for more literature on timber construction within the South African context. It also offers valuable insights into the differing perspectives of individuals with and without timber construction and design experience, providing a basis for further analysis.

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EWPs; engineered wood; technology adoption; Wendy house; buildings



### Introduction

The construction industry is currently at a pivotal juncture, grappling with the dual challenges of meeting increasing demand for infrastructure while addressing significant environmental concerns. Globally, traditional materials such as steel and concrete dominate structural applications in building construction (Meyer 2009, Deng *et al.* 2020), but their production and use contribute substantially to greenhouse gas emissions (Giama and Papadopoulos 2015, Assi *et al.* 2018) and resource depletion (Eřtoková *et al.* 2022). In recognition of the industry's environmental effects, several directives and guidelines have been instituted to encourage the transition towards more sustainable practices (Giama and Papadopoulos 2015). This has led to the exploration of alternative materials that can mitigate these environmental impacts (Zygomalas *et al.* 2016).

South Africa's construction landscape mirrors these global trends, heavily relying on conventional materials such as concrete and brick (Alabi and Fapohunda 2021, van der Westhuyzen and Wium 2021). Concrete production requires massive resource consumption in addition to the high emissions of Carbon dioxide (CO<sub>2</sub>) from cement (Muigai *et al.* 2014), while brickmaking leads to soil erosion, greenhouse gas emissions, and high waste production (Aniyikaiye *et al.* 2021). Both require and utilise large amounts of energy in the form of electricity (Muigai *et al.* 2014, Aniyikaiye *et al.* 2021), with the use of coal being a predominant energy source in the country (Mhlanga and Garidzirai 2020). As widely documented, burning coal contributes to climate change and releases harmful gases, including sulfur dioxide (SO<sub>2</sub>), nitrogen oxides, mercury, and CO<sub>2</sub> (Balat 2007).

Globally, timber has emerged as a compelling alternative to traditional structural materials. As a renewable resource, timber has a lower carbon footprint than steel and concrete (Crafford *et al.* 2017). Innovations in timber technology and engineered wood products (EWPs), such as cross-laminated timber (CLT) and glued laminated timber (glulam), have also enhanced timber's structural capabilities, allowing it to meet the demands of modern construction (Harte 2017). Additionally, the use of timber supports carbon sequestration and aligns with the principles of a circular economy, where materials are reused and recycled, further reducing environmental impact (Mirdad *et al.* 2021). Moreover, the use of timber in the construction of several multi-story buildings around the world now serves as a testament to the possibilities of timber as a structural material, challenging the long-held perception that it is unsuitable for such applications (Svatoř-Ražnjević *et al.* 2022).

Despite the promising attributes of timber, a notable gap exists in research regarding its adoption prospects as a structural material within the South African construction industry. A systematic literature search was conducted using relevant keywords on Scopus and Web of Science, two of the most comprehensive academic databases (Chadegani *et al.* 2013). The search yielded only one result, which was not directly relevant to the topic. Details of the search terms and results are provided in the appendix. This underscores a significant gap in the existing research on the adoption of timber in South Africa. Specifically, there is a lack of studies that explore the barriers and enablers of timber adoption from the perspective of construction stakeholders. This study contributes to the literature by assessing the feasibility of timber adoption, specifically

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examining stakeholder perspectives and the barriers they perceive in using timber as a primary structural material. It provides an in-depth evaluation of the current state of timber use in South Africa, identifying key motivations and challenges related to its adoption. Additionally, this research offers practical recommendations to enhance the integration of timber into the construction industry, addressing a critical gap in the understanding of sustainable building practices within the South African context.

## Literature review

Timber has been a fundamental material in construction for centuries, with its historical use tracing back to ancient civilisations (Beskitt 2016). However, in the modern era, it has been overshadowed by concrete, steel, and brick, which are more prolific in construction projects (Schmidt and Griffin 2013). Variability in the properties of sawn timber (Livas *et al.* 2022), damage caused by exposure of wood surfaces to the elements (Foliente 2000), a series of unfortunate fire outbreaks involving wood buildings in the nineteenth century (Langenbach 2008), and strict building regulations with narrow views of timber use (Schmidt and Griffin 2013) have all contributed to limiting the use of timber in construction.

In recent years, there has been a notable resurgence in the adoption of timber as a primary structural material, particularly with the rise of EWPs such as CLT and glulam (Huang *et al.* 2024). This resurgence has been driven by a growing recognition of timber's environmental benefits, including its low carbon footprint and renewability (Crawford and Cadorel 2017). However, the technical capabilities of modern timber products provide support for timber as a structural construction material in its own right.

Timber has several structural benefits, including a high strength-to-weight ratio that allows for lighter construction projects with strength capabilities comparable to concrete and steel (Mallo and Espinoza 2014, Ahmed and Arocho 2021). This is useful for several reasons. It allows for innovative architectural designs and the construction of larger and more complex structures (Ilgin *et al.* 2023). In areas with poor soil and limited load-bearing capacity, timber's lighter weight can allow for the construction of building projects, which would be much more difficult with concrete (Franzini *et al.* 2018). The material's lightness facilitates prefabrication and makes handling and transit easier (Riala and Ilola 2014). EWP such as CLT and glulam have been developed to enhance these properties, making timber suitable for multi-story and high-rise buildings (Espinoza *et al.* 2016b, Evison *et al.* 2018). CLT's crosswise laminating structure provides enhanced dimensional stability and stiffness, making it suitable for multi-story buildings (Wang *et al.* 2018).

Structural fire safety is a crucial factor to consider when using timber in building construction projects, and mass timber products offer several properties that enhance the fire resistance of timber compared to conventional materials like steel and concrete (Buchanan 2017). One of the critical advantages of mass timber products is their predictable charring behaviour. When exposed to fire, the outer section of timber usually chars. This char layer serves as a good insulator. While it doesn't completely stop heat from reaching the inside of the timber, it slows the heat transfer, keeping the inner core

relatively cooler (Bartlett *et al.* 2019). Timber chars at a relatively consistent rate, which allows for calculating the remaining structural capacity over time (Friquin 2011). This property enables engineers to design timber structures with a clear understanding of how they will perform under fire conditions, allowing for effective fire safety strategies (Wiesner *et al.* 2021).

Furthermore, the use of timber in construction presents significant advantages in terms of time and cost savings, making it an increasingly attractive option for builders and developers. Research indicates that mass timber projects can achieve an average cost saving of around 4% compared to traditional construction methods when considering the total lifecycle costs (Abed *et al.* 2022). This is due to several factors, including timber requiring less skilled labour and fewer person-hours due to its ease of handling and assembly, contributing to reduced labour costs (Penfield *et al.* 2022). Additionally, the lighter weight of timber reduces foundation costs, as less extensive groundwork is needed compared to heavier materials like concrete (Abed *et al.* 2022). In terms of time, the ability to prefabricate building elements with timber and assemble them on the construction site reduces the development timeline compared to conventional materials (Penfield *et al.* 2022). Furthermore, the lack of set and dry times inherent with concrete construction expedites the building timeline and allows other occupations to commence operations sooner (Kremer and Symmons 2015).

Still, the use of timber poses several challenges. Traditional timber structures can ignite easily and may not perform well under fire conditions, leading to rapid structural failure (Christensen *et al.* 2023), while the lighter weight of timber compared to concrete and steel can lead to serviceability issues, such as vibrations and deflections, particularly in long-span applications (Mirdad *et al.* 2021). Wood exposure to moisture is another major challenge as it is naturally hygroscopic, and changes in humidity can cause structural alterations that can impact its qualities (Dietsch *et al.* 2015). This is not limited to solid wood but affects EWP, resulting in losses in the structural integrity of wood products (Shirmohammadi *et al.* 2021). Moreover, moisture in wood leads to termite infestation and biodegradation of the wood material (Ayanleye *et al.* 2022).

Existing studies in developed economies highlight several factors that impact the adoption of timber in the construction industry. Fire resistance and fire safety concerns (Hurmekoski *et al.* 2015, Gosselin *et al.* 2017, Abdulwahid *et al.* 2021), compatibility with building codes and regulations (Mallo and Espinoza 2014, Abdulwahid *et al.* 2021), lack of timber supply (Espinoza *et al.* 2016a, Ahmed and Arocho 2021, Low *et al.* 2021), the stability of timber structures (Bahrami *et al.* 2023), durability concerns (Baiden *et al.* 2005, Mallo and Espinoza 2014), quality concerns (Markström *et al.* 2018) cost concerns (Riala and Ilola 2014, Low *et al.* 2021), lack of skilled labour (Karjalainen *et al.* 2021, O'Ceallaigh *et al.* 2021) are some perceived barriers to the use of timber in the construction industry. On the other hand, the aesthetics of timber buildings (Araya *et al.* 2022), the speedy nature of timber construction (Low *et al.* 2021, O'Ceallaigh *et al.* 2021), the sustainability benefits of timber as a building material (Wahlström *et al.* 2020), and wood's strength-to-weight ratio (Gosselin *et al.* 2017) are some advantages of timber that are driving its use.

Some of these studies have recognised the influence of various location-specific factors, necessitating context-specific

investigations to understand the dynamics at play. For instance, Schuetze (2018) noted that while the initial costs of timber construction can be comparable to conventional materials, local economic conditions can influence these costs significantly. According to Hurmekoski *et al.* (2015), areas which have a long-standing culture of using wood are more likely to have a positive view of timber. Rogers (2010) emphasised that the diffusion of innovations is heavily influenced by contextual settings. In the South African context, the factors that impact the adoption of timber have not been investigated. This research aims to address this gap by exploring the feasibility of timber as a structural material in non-residential construction and offering actionable recommendations tailored to the South African construction industry.

## Methodology

A survey split into three sections was developed using Google Forms to achieve the study's aims. Questionnaire surveys are a prevalent method of data collection in research due to their ability to reach a broad audience quickly (Kelley *et al.* 2003). Another significant benefit of questionnaire surveys is their versatility in addressing various research questions. They can be designed to collect quantitative and qualitative data, allowing researchers to explore complex phenomena from multiple angles (Creswell and Hirose 2019).

Convenience sampling, a non-probabilistic sampling method, was utilised for this study. Non-probability sampling is a valuable method in research that can be more appropriate than probability sampling in specific contexts. According to Sandstrom-Mistry *et al.* (2023), non-probability sampling is beneficial in exploratory studies, preliminary research, or when particular subpopulations are of interest – characteristics that describe this feasibility study. Similarly, convenience sampling can be helpful in exploratory research, where the primary goal is to identify trends rather than to make generalisable claims about a population (Iortyom *et al.* 2018). This exploratory nature is echoed in the findings of Jager *et al.* (2017), who argue that convenience samples can still provide meaningful insights into population effects and subpopulation differences despite their limitations in generalizability. In the application of convenience sampling, a link to the survey was sent to 1100 email addresses belonging to built construction professionals and other notable stakeholders in South Africa gathered from several public databases and recommendations in the buildup to the study as well as in construction professionals' groups on Facebook and LinkedIn. Ninety-six respondents completed the study.

The first section assessed the respondents' backgrounds by determining if they reside or work in South Africa and their experience with timber construction or design. Respondents were also asked to identify their profession among 17 main categories. Two of the 96 respondents who completed the study stated that they do not reside in South Africa. Their responses were, therefore, excluded, leaving 94 responses. The largest group of respondents were engineers, making up 22.3% of the total respondents. Architects and academia comprised the second most prominent groups, each accounting for 21.3% of the respondents. Sawmilling and solid wood

producers comprised 7.4% of respondents, while members of Councils, Institutes, Associations, or Forums comprised 6.4%. A smaller 4.3% of respondents fell under the Forestry category, while 2.1% fell under the government and property developer categories. Other more specialised professions, including building contractors, building inspectors, media or advertising executives, and technology suppliers, comprised 1% of respondents. Respondents were also asked to state whether they had some experience with timber construction or design (TCD), with 50 respondents (53%) reporting having experience (TCDE-Yes) and 44 respondents (47%) with no experience (TCDE-No). The second section collected respondents' ratings of timber compared to traditional materials like brick, concrete, and steel across 24 attributes using a scale of Inferior, Similar and Superior. Table 1 provides the attributes and the scale used.

The results of the second section produced ordinal data that was analysed using descriptive methods with Microsoft Excel. The ordinal data were numerically coded to aid in this activity. Mode values were extracted from the data for analysis. The mode represents the most frequently occurring value in the data set and provides insights into the most common response or category in the ordinal data (Agresti 2010). The final section was an open-ended section where respondents were asked to state the barriers to the adoption of timber in the South African construction industry and their recommendations for increased adoption. Answers from the open-ended survey questions were transferred onto a Microsoft Word document and loaded onto ATLAS.ti for analysis. The data was analysed qualitatively using thematic analysis. Thematic analysis is a technique for finding, investigating, analysing, and documenting themes in data (Braun and Clarke 2006). The themes are patterns found in the data and are essential for characterising a phenomenon connected to a particular research topic. These themes then serve as categories for additional analysis (Braun and Clarke

**Table 1.** Comparative analysis of timber with conventional materials (concrete, brick and steel) across various attributes.

Attribute	Inferior	Similar	Superior
General quality			
Durability			
Safety of occupants during a fire			
Likelihood of severe damage during a fire			
Dimensional stability			
Strength-to-weight ratio			
Ease of construction			
Appearance			
Visibility			
Noise suppression			
Heat and cold insulation			
Speed of construction			
Environmental sustainability			
Local building skills			
Local design skills			
Local supply of lumber (availability)			
Local supply of engineered wood (availability)			
Material standards (South African National Standards)			
Building regulations and standards (South African National Standards)			
Ease of building approval			
Insurability			
Financing			
Ease of design			

2006). The analysis began with familiarisation, during which the researcher thoroughly reviewed and annotated the raw data to identify initial patterns. Open coding was then applied to segment the data into meaningful units, which were iteratively grouped into broader themes based on recurring ideas. These themes were reviewed and refined to ensure they accurately represented the data. To quantify the prevalence of these themes, they were counted based on the number of respondents who alluded to them. The resulting data were used to create graphs presented in the results section to represent the findings visually.

## Results and discussion

### Comparison of timber against conventional material (brick, concrete and steel)

For the second section of the survey, respondents were asked to rate timber against brick, concrete and steel against 24 attributes as outlined in the previous section. The results of this exercise are provided below (Figure 1).

Respondents rated timber as “Inferior” to other materials on eight attributes: the *availability of local building skills, ease of building approval, financing, the likelihood of damage during a fire, local supply of EWP, and noise suppression* abilities. A “Similar” rating was applied for another eight attributes: the *safety of occupants in a fire, local lumber supply, durability, the presence of building regulations, material standards, design ease, dimensional stability and quality*. Respondents rated timber as “Superior” to other materials on the final eight attributes: *heat and cold insulation, strength-to-weight ratio (STW),*

*environmental sustainability, visibility, proof of sustainability, appearance, construction ease and speed.*

The data were further analysed based on respondents’ experience with timber construction or design (TCD) experience. Respondents with TCD experience rated timber as “Inferior” to other materials on five attributes: *availability of local building skills, insurability, local design skills, and likelihood of damage during a fire and local lumber supply*. They rated timber as “Similar” on 13 attributes: *financing, ease of obtaining building approval, noise suppression, the safety of occupants in a fire, local supply of EWP, durability, local supply of lumber, building regulations, material standards, heat and cold insulation, dimensional stability, design ease and quality*. Finally, they rated timber as “Superior” on six attributes: *speed of construction, ease of construction, appearance, visibility, environmental sustainability, and strength-to-weight ratio*. Figure 2 presents the ratings of respondents with TCD experience.

For respondents with no TCD experience, timber was rated as “Inferior” on nine attributes: *local supply of EWP, local building skills, insurability, local design skills, building approval, material standards, financing, local lumber supply and noise suppression*. They rated timber as “Similar” to conventional materials in seven attributes: *quality, dimensional stability, strength-to-weight ratio, the safety of occupants in a fire, durability, likelihood of damage during a fire, and building regulations*. They rated timber as “Superior” on the final eight attributes: *speed of construction, ease of construction, appearance, visibility, heat and cold insulation, proof of sustainability, environmental sustainability and ease of design*. Figure 3 presents the ratings of respondents with no TCD experience.

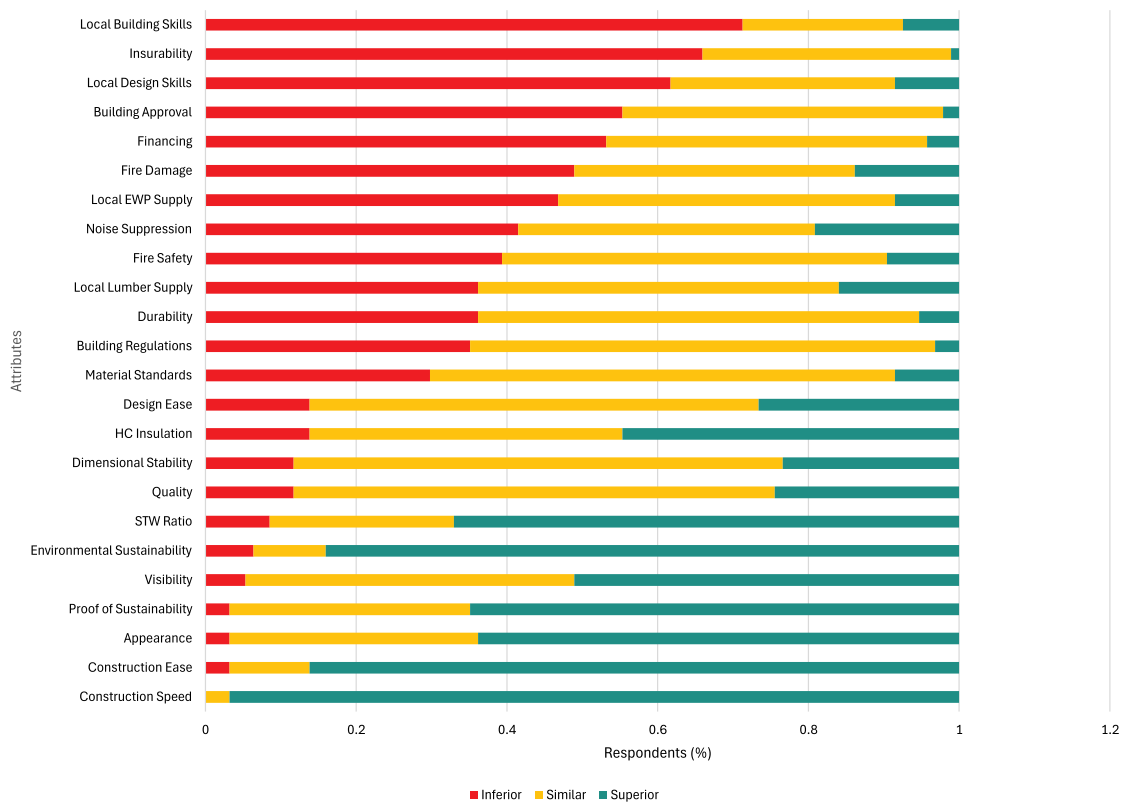


Figure 1. Respondents ratings of timber compared with other construction materials (brick, concrete and steel).

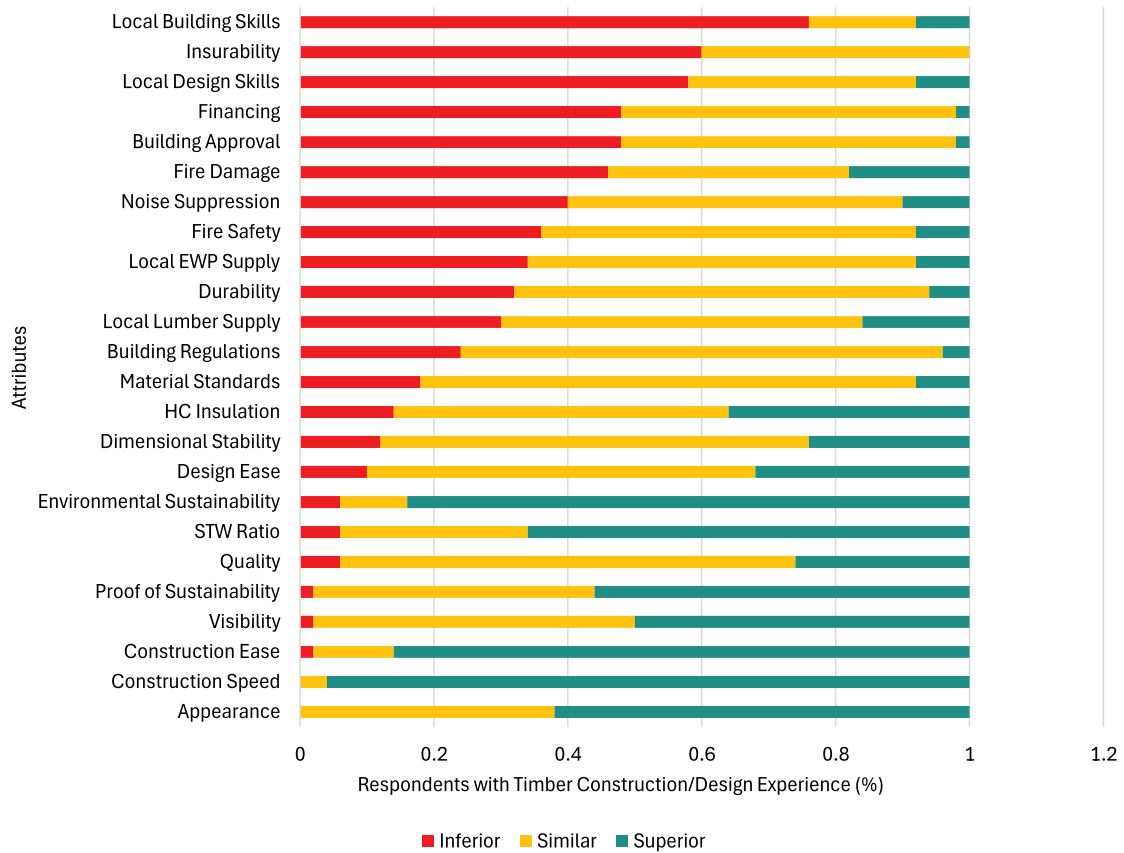


Figure 2. Ratings of respondents with timber construction or design experience.

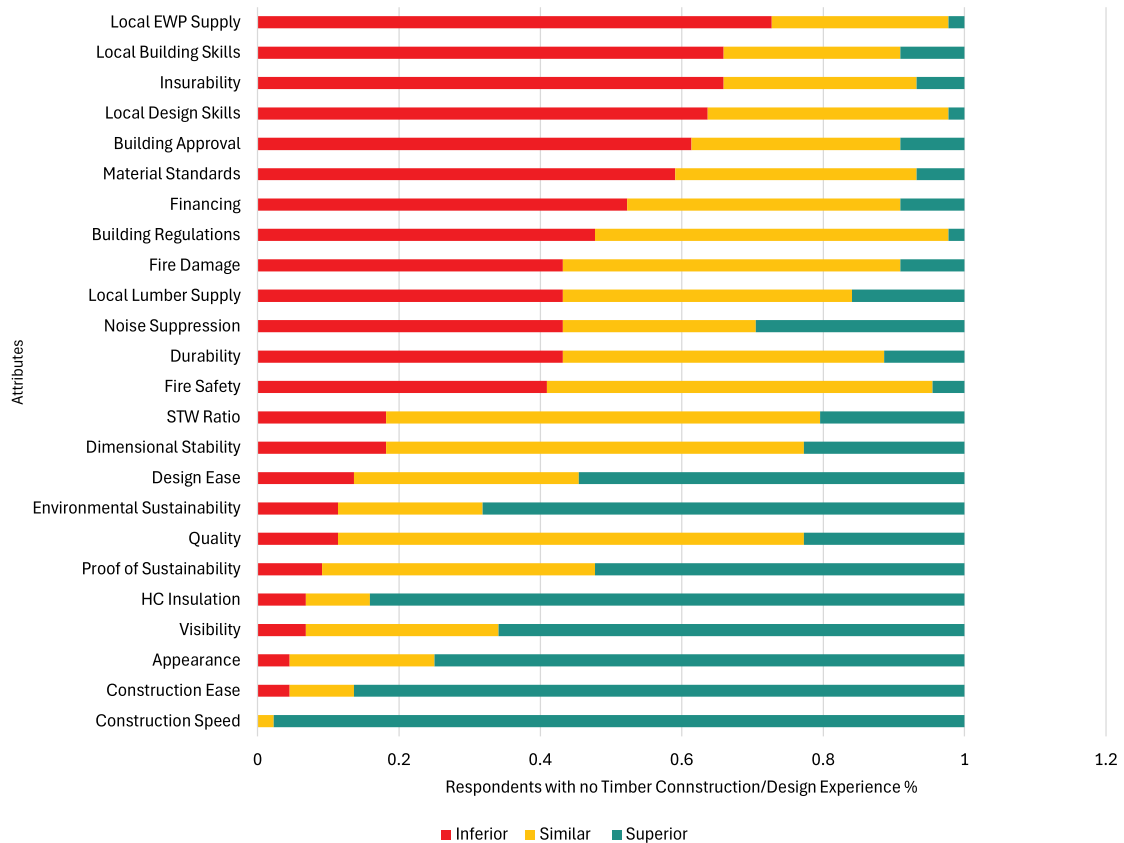


Figure 3. Ratings of respondents with no timber construction or design experience.

Across both sets of respondents, some trends can be observed. Across 15 attributes, respondents with no TCD experience and those with TCD experience align in their rating of timber as “Superior” to conventional materials such as brick, concrete and steel on ease of construction, speed of construction, appearance, visibility, proof of sustainability and environmental sustainability; “Similar” to conventional materials on safety of occupants in a fire, durability and building regulation; and “Inferior” on the availability of local building skills, local design skills and local supply of EWP. However, they had different ratings on nine attributes: design ease, heat and cold insulation, strength-to-weight ratio, local lumber supply, the likelihood of damage in a fire, financing, material standards and building approval.

### Feasibility of using timber in construction

For the third section of the survey, respondents were asked to identify the barriers to adopting timber construction in South Africa and provide recommendations for improving its adoption. Their responses are analysed below.

Across all respondents, the perception of timber by others, lack of skills in timber construction, cost concerns and lack of knowledge made up 50% of the perceived barriers to the

adoption of timber in South Africa. Figure 4 presents the themes identified as perceived barriers to the adoption of timber in South Africa. The thickness of the bars is used to represent the frequency of the themes in the results. Thicker bars represent more mentions.

Concerns about fire, limited availability of timber in South Africa, lack of government support, concerns about the performance of timber, resistance to timber construction by the public, a culture of building with brick-and-mortar, resistance to change within the construction industry, poor quality of local timber were the other perceived barriers highlighted.

Still, there were some noticeable differences between respondents with timber construction or design experience and those without experience. For respondents with TCD experience, the negative perception of timber by others, concerns about the cost of timber, skills gap within the industry, lack of knowledge and resistance to change within the industry were the top five perceived barriers. Additionally, compatibility of timber construction with the South African climate, lack of funding for timber construction, and resistance to change within the construction industry were perceived factors unique to respondents with TCD experience. Figure 5 presents the complete list of perceived barriers to timber construction in South Africa by respondents with TCD experience.

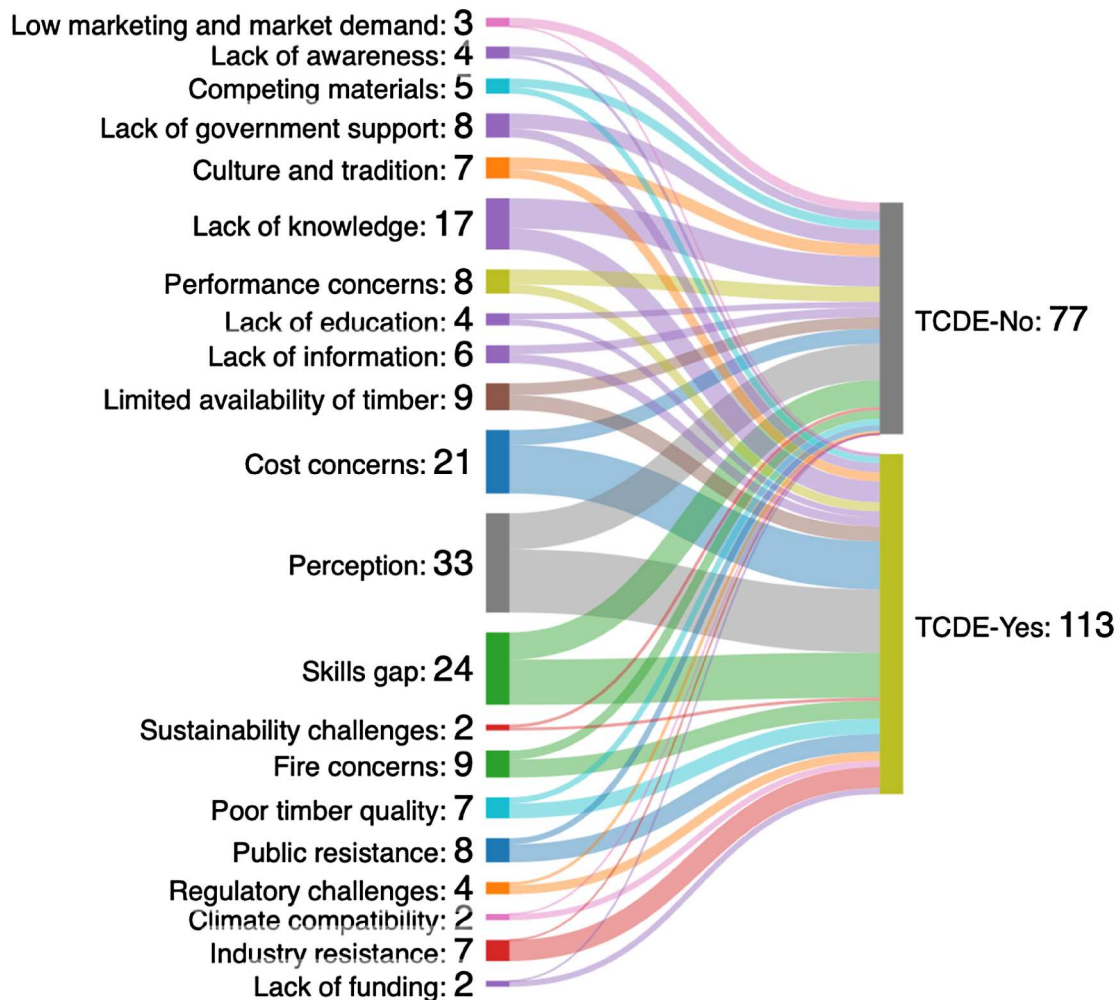


Figure 4. Perceived barriers to the adoption of timber construction in South Africa.

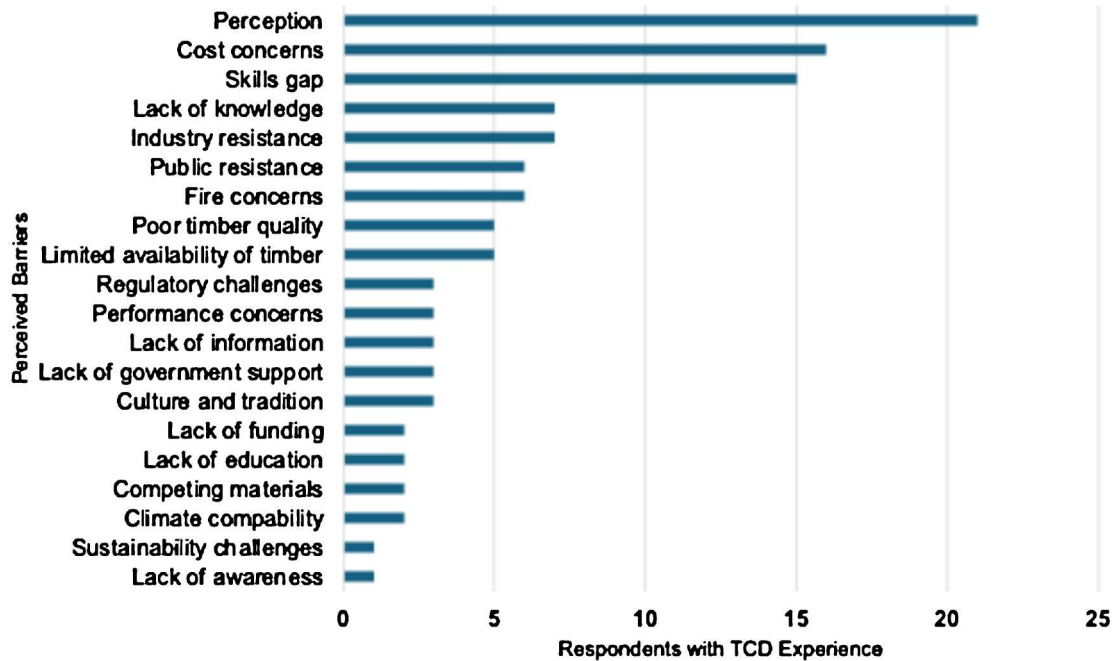


Figure 5. Perceived factors according to respondents with timber construction or design experience.

For respondents with no TCD experience, while the negative perception of timber was still the most common factor, it was closely followed by lack of knowledge, lack of skills, performance concerns, lack of government support and cost concerns. Additionally, low marketing and market demand was highlighted as a perceived factor by respondents in this group, a factor not mentioned by respondents with TCD experience. Figure 6 presents the complete list of perceived barriers to timber construction in South Africa by respondents with no TCD experience.

The most common reason for the low prevalence of timber construction in South Africa, according to respondents in this study, is the negative perception of wood within the

construction industry and in the public domain. According to respondents with TCD experience, some of the perceptions include the association of timber buildings with the less fortunate rather than as a premium or high-end building material, and that timber is only good enough to be used for Wendy Houses – a reference to a timber building typically on an employer's property used as a live-in domestic worker housing or a shack for storing tools, animal feed or other materials that would not be typically stored in the main house. There are also perceptions regarding the risks involved due to the scarcity of local skills and proven project experience. Other perceptions that respondents in this group have noted include the idea that masonry is a superior practice and

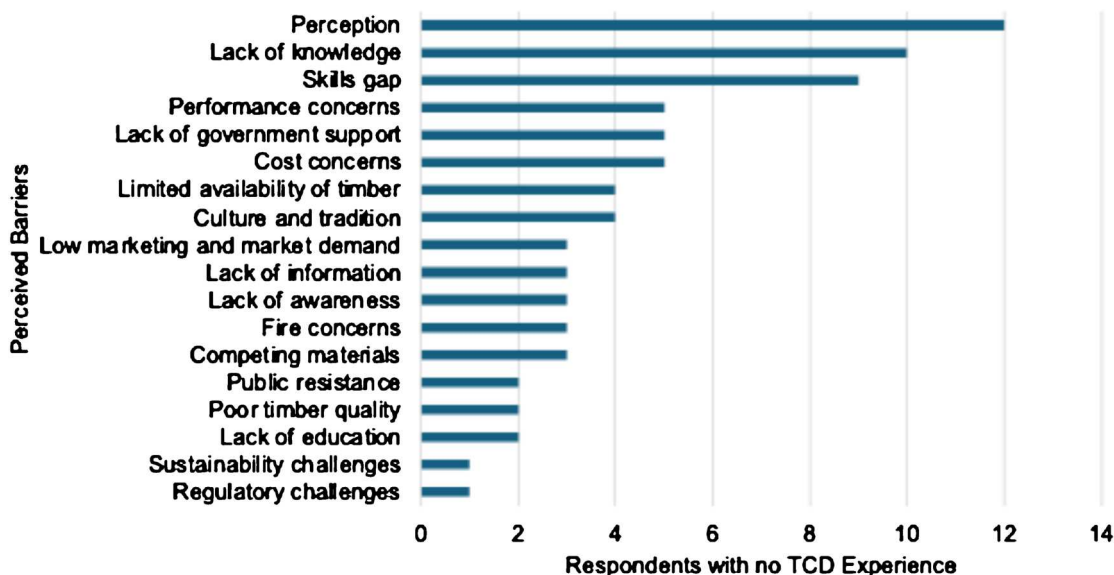


Figure 6. Perceived barriers according to respondents with no timber construction and design experience.

perceptions about the cost of timber. One respondent highlighted a common perception of timber as a cheap and temporary material, while another pointed out an opposing view that timber is seen as expensive and inaccessible.

For respondents with no TCD experience, the negative perceptions about timber that they have observed revolve around the quality and properties of timber, including flammability, sustainability and structural strength. Timber is perceived as a highly flammable material and a potential fire hazard. It is also considered weaker than brick as a structural material. According to both sets of respondents, these perceptions have historical precedents and are challenging to overcome. Several authors, including Laguarda Mallo and Espinoza (2015), Kremer and Symmons (2016), Markström *et al.* (2018), and Ahmed and Arocho (2021) have suggested the lack of awareness as a reason for the negative perceptions of timber. According to Giesekam *et al.* (2014), while these negative perceptions often differ from reality, they influence the behaviour of stakeholders.

Another perceived limitation to the adoption of timber construction is the need for more skilled workers with knowledge of timber construction within the industry. This skill shortage is across various trades, including contractors, developers, engineers, designers and carpenters. This lack of skill is linked to a need for knowledge in areas such as timber's environmental, thermal, acoustic and aesthetic qualities. Kitek Kuzman *et al.* (2018) have noted that architects require more technical information and training to understand the potential of wood products. Similarly, Kuperstein Blasco *et al.* (2021) reported that builders in their study believed they needed more wood construction expertise. Understandably, limited knowledge and skill in working with EWP inhibit its adoption. According to some respondents with TCD experience, there is minimal knowledge in the South African construction industry about timber construction, with the sector still plagued with misinformation about the safety and durability of timber. This lack of knowledge also extends to clients who do not request timber buildings as they have limited knowledge of wood as a building material.

One probable cause of this limited knowledge is poor knowledge transfer within the industry, according to one respondent. For another respondent, the timber sector must do more to educate the construction industry and the public about the possibilities of building with timber. This perceived lack of information about wood was another common barrier for respondents. They noted the need for documented information about timber construction, specifically the availability of designs, building plans and associated risks. This perceived lack of information and knowledge transfer has contributed to a general lack of awareness within the industry and a public that is uninformed about the possibilities of timber construction. Lundberg *et al.* (2019) contend that since the construction business is project-based, innovations usually occur inside specific construction projects, are incremental, and are founded on current knowledge and experience. Furthermore, information about these innovations is not traditionally communicated outside of the project context or among industry peers, and the decentralised nature of the industry leads to the formation of institutional barriers to learning and the free

flow of information across companies and even within projects (Giesekam *et al.* 2014).

Respondents with no TCD experience observed that consumers drive market demand, and their lack of awareness or knowledge means there is limited demand for timber construction. Consumers have misconceptions regarding timber's technical attributes, so stakeholders in the industry, including contractors, professionals and suppliers, must take responsibility for educating consumers about the potential benefits of timber (Kuperstein Blasco *et al.* 2021, Penfield *et al.* 2022). One fringe concern expressed by multiple respondents with TCD experience is that timber is unusable in South Africa's climate. The hot and dry weather and seasonal fire outbreaks that level brick buildings were of notable concern. A few respondents also mentioned the lack of funding support for timber construction.

Respondents recommended increased promotion to improve the prospects of timber construction adoption in South Africa. According to Penfield *et al.* (2022), before any innovation can gain widespread adoption, people must be aware of it. For timber to gain widespread acceptance in the construction industry, stakeholders must know it. When people are aware, they are much more likely to go through the stages of adoption and share the innovation with others. For instance, in a survey of engineering and construction professionals, Schmidt and Griffin (2013) linked knowledge about CLTs with the likelihood of utilisation in construction. Respondents in our study suggested promoting the benefits of timber construction, including the ease of construction, fire safety, its place in the sustainability movement, speed of construction and its associated financial benefits. According to Kremer and Symmons (2016), industry stakeholders can lead in promoting timber construction by submitting bids for government-funded projects using "timber first" policies enacted in Europe and America as case studies. These case studies may also serve as a guide to help shape the local market.

In their research, Franzini *et al.* (2018) highlighted the lightness of wood buildings as a potential driver for their increased adoption. In areas with poor soil where concrete and other heavier materials would sink, timber allows for the construction of stable buildings whose weight can be borne by the soil (Hurmekoski *et al.* 2015). According to respondents, promotion efforts should also increase awareness about the various timber construction methodologies, including hybrid construction.

Access to information was another common recommendation. Respondents requested more access to information about timber building design possibilities and requirements, maintenance measures, and product information. They also requested access to information about engagement opportunities and learning opportunities to discuss timber construction and sawmilling in South Africa. Several authors have also prescribed increasing knowledge, awareness and access to information on timber products and construction as a solution for increased adoption (Mallo and Espinoza 2014, Riala and Ilola 2014, Markström *et al.* 2018, Ahmed and Arocho 2021).

A key goal for the timber construction sector should be the construction and promotion of pilot timber construction projects. According to respondents, these projects will provide practical proof and may serve as case studies that showcase

the cost benefits, fire safety and environmental benefits of timber. Such projects should be collaborative ventures between manufacturers, producers, designers, builders, and municipalities. They should be marketed and showcased to the public to increase visibility. According to Laguarda Mallo and Espinoza (2015), how users feel about a product is just as important as its actual performance and affects its adoption. Hurmekoski *et al.* (2015) suggested that if users are exposed to wooden indoor surfaces, they may overcome the psychological perceptions of the strength of wood as an indoor construction material, turning a perceived weakness of timber into a strength. According to Franzini *et al.* (2018), users may drive the adoption of timber as global awareness about the potential benefits of timber grows. For instance, market factors such as the creation of new businesses in the industry, the availability of numerous building systems made from wood products and a growing acceptance of wood products in the construction sector are drivers for the use of wood in Portugal (Oliveira *et al.* 2013).

Access to funding would enable timber projects, and respondents felt the government could provide more investment in timber construction. Authorities in other regions have served as positive change agents as they pushed for sustainability in the construction industry and have driven the adoption of wood products (Wang *et al.* 2014). Countries like Finland and the United Kingdom have adopted this driver to increase the use of wood products in construction due to its environmental and economic benefits (Hurmekoski *et al.* 2015). In the United Kingdom, environmental legislation has been linked to an uptick in the use of wood, while Finland's government changed fire standards to permit building constructions with wood to reach eight floors (Kuperstein Blasco *et al.* 2021). Respondents noted that government investment, such as tax reliefs for building with timber, grants, and financing options for companies that venture into timber construction, will contribute to the government's ability to meet its sustainable development goals.

Respondents also perceived education and training as potential enablers for adopting timber construction. For instance, in an analysis of industrial engineering curricula across South African universities, Hassan and Grobbelaar (2024) identified a distinct lack of timber and EWP content despite evidence of the application of industrial engineering principles in timber construction. Developing a timber education curriculum in universities could improve technical knowledge about timber construction. Similarly, workshops, training and continuing professional development (CPD) courses should be prioritised for professionals in the built environment. Additionally, there should be public awareness initiatives to educate the public. Informing stakeholders about the properties of products takes time and effort. In the long term, however, providing accurate and current information will likely yield returns (Kitek Kuzman *et al.* 2018). Respondents also recommended a concerted effort by the timber construction sector to place professionals with timber construction experience in bodies such as the National Home Builders Registration Council (NHBRC) and promotional endeavours targeted at municipalities to raise awareness of timber construction, leading to the approval of projects.

A perceived barrier to the adoption of timber in the construction industry is the need for more building standards or regulations for prospective builders. Hence, respondents also recommended the development of building codes and standards that would be acceptable to the NHBRC and municipalities. Others aware of these codes and standards called for updates to match contemporary needs and the training of officials to ensure that authorities and regulators are well-informed. For instance, there is a need for more building compliance officers with knowledge of timber technology. According to Kuperstein Blasco *et al.* (2021), the desire for many municipalities across Finland to become carbon neutral by the end of the decade is a significant driver for using renewable materials like wood in construction.

According to respondents, establishing a timber supply chain would also improve adoption rates. The supply of timber could be increased by removing existing barriers to the planting of trees for commercial purposes and the establishment of more production facilities. Furthermore, research on timber should be encouraged, and results should be published. Respondents encouraged research on specific areas, including cost comparisons with conventional materials, fire safety, feasibility studies and timber property testing. The results of these research activities should be published and made available to the relevant stakeholders. Hurmekoski *et al.* (2015) observed that despite years of evidence showing the necessity for resource efficiency in the industry, most research about the industry has focused on conventional materials, perhaps due to their prevalence, and has prioritised potential recycling options rather than alternative renewable materials.

Many of the factors observed in this study impact the perceived feasibility of using timber as a structural construction material. According to Rogers (2010), the adoption of innovations is influenced by the perceived attributes of the innovation. The barriers and potential enablers identified in the results are all respondents' perceptions and, as demonstrated, may not align with empirical evidence. While these perceptions may often differ from reality, they influence the behaviour of stakeholders.

## Conclusion

This research explored the feasibility of adopting timber as a structural material in the South African construction industry by examining the perceptions of various stakeholders in the industry. Using a questionnaire survey with a mixture of closed-ended and open-ended questions, respondents were invited to compare timber with conventional materials across 24 attributes, share their views on the factors limiting timber construction adoption, and offer recommendations to enhance its adoption in South Africa. The ratings and opinions of 94 respondents were analysed for this study. The analysis provided generally positive ratings of timber compared to brick, concrete and steel on attributes such as the ease of construction, speed of construction, appearance of timber and sustainability. Respondents were more pessimistic about timber when considering the availability of timber and timber construction skillsets in South Africa. Beyond these attributes, respondents with timber construction or design experience differed from those without experience in characteristics such

as the strength-to-weight ratio of timber, the presence of material standards for timber, and the ease of gaining building approval. This study has also provided insights into perceived challenges facing timber adoption and the potential enablers that may influence increased adoption. The negative perception of timber as a construction material in South Africa, the lack of timber construction skillset and knowledge, and cost concerns have been highlighted as significant barriers. Respondents with TCD experience uniquely highlighted challenges such as the lack of funding support and climate concerns, whereas those without experience identified low marketing of timber as a distinctive issue.

One recommendation is to conduct further empirical studies to determine whether the differences between individuals with and without timber construction and design experience are statistically significant, aiding proponents of timber construction in understanding the extent and impact of these factors. We also agree with the respondents' recommendation that timber construction stakeholders commit to promoting new technologies to combat these misperceptions. This study is limited because it is not representative of the South African construction industry; hence, perceptions revealed in this study may only be deemed applicable to the respondents in the survey. Similarly, although less than one per cent of buildings in South Africa are structurally timber-based, over 50% of our respondents have some familiarity with timber construction. This suggests that results are skewed towards knowledge of timber construction. However, we lean on the leverage-salience theory of survey participation. A potential reason for this skewness is that people who receive a survey request on a topic that interests them are likelier to participate than those less interested in the subject. This study contributes to theory by highlighting the influence of stakeholder perceptions on the adoption of timber construction, providing a nuanced understanding of adoption barriers and enablers. Practically, the findings offer actionable insights for timber proponents to tailor strategies that address specific concerns of experienced and inexperienced stakeholders, fostering broader acceptance of timber as a structural material. Ultimately, this study will serve as a starting point for future research on timber construction in South Africa.

### Ethics statement

The researchers sought approval from the Research Ethics Committee of their institution on the 21st of June, 2023. It was conditionally approved on the 30th of June, 2023. The protocol number is EBIT/195/2023.

### Disclosure statement

No potential conflict of interest was reported by the author(s).

### Data availability statement

Data supporting the findings of this study are available on request from the corresponding author. The data are not publicly available due to ethics rules at the authors' institution.

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### References

- Abdulwahid, M.Y., Galobardes, I., and Radoine, H., 2021. Understanding the use of timber in semi-Arid regions: Kurdistan region of Iraq, a case study. *Sustainability*, 13 (21), 11845. doi:10.3390/su132111845.
- Abed, J., et al., 2022. A review of the performance and benefits of mass timber as an alternative to concrete and steel for improving the sustainability of structures. *Sustainability*, 14 (9), 5570. doi:10.3390/su14095570.
- Agresti, A., 2010. *Analysis of ordinal categorical data*. [online] Hoboken, NJ: Wiley & Sons Inc. Available from: [https://books.google.co.za/books?hl=en&lr=&id=VVle4BPDR7kC&oi=fnd&pg=PR9&dq=Analysis+of+Ordinal+Categorical+Data&ots=cW85C5XyXK&sig=QB4\\_1rMqpNxc9hdhuHAAeS77000&redir\\_esc=y#v=onepage&q=Analysis%20of%20Ordinal%20Categorical%20Data&f=false](https://books.google.co.za/books?hl=en&lr=&id=VVle4BPDR7kC&oi=fnd&pg=PR9&dq=Analysis+of+Ordinal+Categorical+Data&ots=cW85C5XyXK&sig=QB4_1rMqpNxc9hdhuHAAeS77000&redir_esc=y#v=onepage&q=Analysis%20of%20Ordinal%20Categorical%20Data&f=false) [Accessed 20 February 2025].
- Ahmed, S., and Arocho, I., 2021. Feasibility assessment of mass timber as a mainstream building material in the US construction industry: level of involvement, existing challenges, and recommendations. *Practice Periodical on Structural Design and Construction* [online], 26 (2), 12. doi:10.1061/(asce)sc.1943-5576.0000574.
- Alabi, B., and Fapohunda, J., 2021. Effects of increase in the cost of building materials on the delivery of affordable housing in South Africa. *Sustainability (Switzerland)* [online], 13 (4), 1–12. doi:10.3390/su13041772.
- Aniyikaiye, T.E., et al., 2021. Traditional brick making, environmental and socio-economic impacts: a case study of Vhembe district, South Africa. *Sustainability*, 13 (19), 10659. doi:10.3390/su131910659.
- Araya, R., et al., 2022. Development of sustainable timber construction in Ibero-America: state of the art in the region and identification of current international gaps in the construction industry. *Sustainability*, 14 (3), 1170. doi:10.3390/su14031170.
- Assi, L., et al., 2018. Sustainable concrete: building a greener future. *Journal of Cleaner Production*, 198, 1641–1651. doi:10.1016/J.JCLEPRO.2018.07.123.
- Ayanleye, S., et al., 2022. Durability and protection of mass timber structures: a review. *Journal of Building Engineering*, 46, 103731. doi:10.1016/j.jobee.2021.103731.
- Bahrami, A., Jakobsson, J., and Söderroos, T., 2023. Factors influencing choice of wooden frames for construction of multi-story buildings in Sweden. *Buildings*, 13 (1), 217. doi:10.3390/buildings13010217.
- Baiden, B.K., Badu, E., and Menz, F.S., 2005. Exploring the barriers to the use and potential of timber for housing construction in Ghana. *Construction and Building Materials*, 19 (5), 347–352. doi:10.1016/J.CONBUILDMAT.2004.08.003.
- Balat, M., 2007. Influence of coal as an energy source on environmental pollution. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 29 (7), 581–589. doi:10.1080/15567030701225260.
- Bartlett, A.I., Hadden, R.M., and Bisby, L.A., 2019. A review of factors affecting the burning behaviour of wood for application to tall timber construction. *Fire Technology*, 55 (1), 1–49. doi:10.1007/s10694-018-0787-y.
- Beskitt, S., 2016. *An exploration of structural timber innovation*. [online] University of Akron. Available from: [https://ideaexchange.uakron.edu/honors\\_research\\_projects/329](https://ideaexchange.uakron.edu/honors_research_projects/329) [Accessed 26 Dec 2024].
- Braun, V., and Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3 (2), 77–101. doi:10.1191/1478088706qp063oa.
- Buchanan, A.H., 2017. Fire resistance of multistorey timber buildings. In: K. Harada, K. Matsuyama, K. Himoto, Y. Nakamura, and K. Wakatsuki, eds. *Fire science and technology 2015*. Singapore: Springer Singapore, 9–16. doi:10.1007/978-981-10-0376-9\_2.
- Chadegani, A.A., et al., 2013. A comparison between two main academic literature collections: web of science and Scopus databases. *Asian Social Science*, 9 (5), 18–26. doi:10.5539/ass.v9n5p18.
- Christensen, E.G., et al., 2023. Protection and thermal exposure of clt ceiling and floor surfaces. In: A. Q. Nyruod, K. A. Malo, K. Nore, K. W. L. Alsén, S.

- Tulebekova, E. R. Stæhr, G. Bergh, and W. Wuyts, eds. *World conference on timber engineering (WCTE 2023)*. As: World Conference on Timber Engineering (WCTE 2023), 1778–1787. doi:10.52202/069179-0236.
- Crafford, P.L., Blumentritt, M., and Wessels, C.B., 2017. The potential of South African timber products to reduce the environmental impact of buildings. *South African Journal of Science*, 113 (9/10), 8. doi:10.17159/sajs.2017/20160354.
- Crawford, R.H., and Cadorel, X., 2017. A framework for assessing the environmental benefits of mass timber construction. *Procedia Engineering*, 196, 838–846. doi:10.1016/j.proeng.2017.08.015.
- Creswell, J.W., and Hirose, M., 2019. Mixed methods and survey research in family medicine and community health. *Family Medicine and Community Health*, 7 (2), e000086. doi:10.1136/fmch-2018-000086.
- Deng, E.F., et al., 2020. Seismic performance of mid-to-high rise modular steel construction – a critical review. *Thin-Walled Structures*, 155, 106924. doi:10.1016/J.TWS.2020.106924.
- Dietsch, P., et al., 2015. Methods to determine wood moisture content and their applicability in monitoring concepts. *Journal of Civil Structural Health Monitoring*, 5 (2), 115–127. doi:10.1007/s13349-014-0082-7.
- Espinoza, O., et al., 2016a. Status of cross-laminated timber in North America. In: *WCTE 2016 – World Conference on Timber Engineering*. [online] Vienna University of Technology. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85010976705&partnerID=40&md5=8ba2eb73fac65a29f69959b30dc8c8dbf>.
- Espinoza, O., et al., 2016b. Cross-Laminated timber: status and research needs in Europe. *Bioresources* [online], 11 (1), 281–295. Available from: <<Go to ISI>://WOS:000367732700025>.
- Eštoková, A., Wolfová Fabiánová, M., and Ondová, M., 2022. Concrete structures and their impacts on climate change and water and raw material resource depletion. *International Journal of Civil Engineering* [online], 20 (6), 735–747. doi:10.1007/s40999-022-00701-8.
- Evison, D.C., Kremer, P.D., and Guiver, J., 2018. Mass timber construction in Australia and New Zealand-status, and economic and environmental influences on adoption. *Wood and Fiber Science* [online], 50, 128–138. doi:10.22382/wfs-2018-046.
- Foliente, G., 2000. History of timber construction. In: J.R. Loferski, A.J. Salenikovich and E.G. Stern, eds. *Wood structures: a global forum on the treatment, conservation, and repair of cultural heritage*. 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959: ASTM International, 3–3–20. doi:10.1520/STP133705.
- Franzini, F., Toivonen, R., and Toppinen, A., 2018. Why not wood? benefits and barriers of wood as a multistory construction material: perceptions of municipal civil servants from Finland. *Buildings* [online], 8 (11), 159. Available from: <https://www.mdpi.com/2075-5309/8/11/159>.
- Friquin, K.L., 2011. Material properties and external factors influencing the charring rate of solid wood and glue-laminated timber. *Fire and Materials*, 35 (5), 303–327. doi:10.1002/fam.1055.
- Giamia, E., and Papadopoulos, A.M., 2015. Assessment tools for the environmental evaluation of concrete, plaster and brick elements production. *Journal of Cleaner Production*, 99, 75–85. doi:10.1016/J.JCLEPRO.2015.03.006.
- Giesekam, J., et al., 2014. The greenhouse gas emissions and mitigation options for materials used in UK construction. *Energy and Buildings* [online], 78, 202–214. doi:10.1016/j.enbuild.2014.04.035.
- Gosselin, A., et al., 2017. Main motivations and barriers for using wood in multi-story and non-residential construction projects. *BioResources* [online], 12 (1), 546–570. doi:10.15376/biores.12.1.546-570.
- Harte, A.M., 2017. Mass timber – the emergence of a modern construction material. *Journal of Structural Integrity and Maintenance*, 2 (3), 121–132. doi:10.1080/24705314.2017.1354156.
- Hassan, F., and Grobbelaar, S., 2024. Developing an industrial engineering capabilities framework for the adoption of engineered wood products in the South African construction industry. *South African Journal of Industrial Engineering*, 35 (3), 148–168. doi:10.7166/35-3-3088.
- Huang, H., Su, S., and Li, L., 2024. Advancing timber construction: historical growth, research frontiers, and time series forecasting. *Journal of Asian Architecture and Building Engineering*, 1–30. doi:10.1080/13467581.2024.2373829.
- Hurmekoski, E., Jonsson, R., and Nord, T., 2015. Context, drivers, and future potential for wood-frame multi-story construction in Europe. *Technological Forecasting and Social Change*, 99, 181–196.
- Ilgın, H.E., Karjalainen, M., and Pelsmakers, S., 2023. Contemporary tall residential timber buildings: what are the main architectural and structural design considerations? *International Journal of Building Pathology and Adaptation*, 41 (6), 26–46. doi:10.1108/IJBPA-10-2021-0142.
- lortyom, E.T., Mazinyo, S.P., and Nel, W., 2018. Analysis of the economic impact of rural enterprise development hub project on maize farmers in Mqanduli, South Africa. *Indian Journal Of Agricultural Research*, 52 (3) . doi:10.18805/IJARE.A-319.
- Jager, J., Putnick, D.L., and Bornstein, M.H., 2017. II. More than just convenient: the scientific merits of homogeneous convenience samples. *Monographs of the Society for Research in Child Development*, 82 (2), 13–30. doi:10.1111/mono.12296.
- Karjalainen, M., Ilgin, H.E., and Tulonen, L., 2021. Main design considerations and prospects of contemporary tall timber apartment buildings: views of key professionals from Finland. *Sustainability*, 13 (12), 6593. doi:10.3390/su13126593.
- Kelley, K., et al., 2003. Good practice in the conduct and reporting of survey research. *International Journal for Quality in Health Care*, 15 (3), 261–266. doi:10.1093/intqhc/mzg031.
- Kitek Kuzman, M., et al., 2018. Architect perceptions of engineered wood products: an exploratory study of selected countries in Central and Southeast Europe. *Construction and Building Materials*, 179, 360–370. doi:10.1016/J.CONBUILDMAT.2018.05.164.
- Kremer, P.D., and Symmons, M.A., 2015. Mass timber construction as an alternative to concrete and steel in the Australia building industry: a PESTEL evaluation of the potential. *International Wood Products Journal*, 6 (3), 138–147.
- Kremer, P.D., and Symmons, M.A., 2016. Overcoming psychological barriers to widespread acceptance of mass timber construction in Australia. *Forest & Wood Products*.
- Kuperstein Blasco, D., et al., 2021. Wood material selection in school building procurement – a multi-case analysis in Finnish municipalities. *Journal of Cleaner Production*, 327, 129474. doi:10.1016/J.JCLEPRO.2021.129474.
- Laguarda Mallo, M.F., and Espinoza, O., 2015. Awareness, perceptions and willingness to adopt cross-laminated timber by the architecture community in the United States. *Journal of Cleaner Production* [online], 94, 198–210. doi:10.1016/j.jclepro.2015.01.090.
- Langenbach, R., 2008. Building tall with timber: a paean to wood construction. *Structural Engineering International*, 18 (2), 130–132.
- Livas, C., Ekevad, M., and Öhman, M., 2022. Experimental analysis of passively and actively reinforced glued-laminated timber with focus on ductility. *Wood Material Science & Engineering*, 17 (2), 129–137. doi:10.1080/17480272.2020.1869998.
- Low, S.P., Gao, S., and Ng, S.K., 2021. The adoption of mass-engineered timber (MET) in the Singapore construction industry: barriers and drivers. *Journal of Cleaner Production*, 327, 129430. doi:10.1016/j.jclepro.2021.129430.
- Lundberg, M., Engström, S., and Lidelöv, H., 2019. Diffusion of innovation in a contractor company: the impact of the social system structure on the implementation process. *Construction Innovation* [online], 19 (4), 629–652. doi:10.1108/CI-08-2018-0061.
- Mallo, M.F.L., and Espinoza, O.A., 2014. Outlook for cross-laminated timber in the United States. *BioResources*, 9 (4), 7427–7443.
- Markström, E., et al., 2018. Swedish architects view of engineered wood products in buildings. *Journal of Cleaner Production*, 181, 33–41. doi:10.1016/j.jclepro.2018.01.216.
- Meyer, C., 2009. The greening of the concrete industry. *Cement and Concrete Composites*, 31 (8), 601–605. doi:10.1016/J.CEMCONCOMP.2008.12.010.
- Mhlanga, D., and Garidzirai, R., 2020. Energy demand and race explained in South Africa: a case of electricity. *Eurasian Journal of Business and Management*, 8 (3), 191–204. doi:10.15604/ejbm.2020.08.03.003.
- Mirdad, M.A.H., et al., 2021. Sustainability design considerations for timber-concrete composite floor systems. *Advances in Civil Engineering*, 2021 (1), doi:10.1155/2021/6688076.
- Muigai, R., Alexander, M.G., and Moyo, P., 2014. Cradle-to-gate environmental impacts of the concrete industry in South Africa. *Journal of the South African Institution of Civil Engineering=Joernaal van die Suid-Afrikaanse Instituut van Siviele Ingenieurswese*, 56 (1), 108.

- O'Ceallaigh, C., et al., 2021. Perception and use of timber in construction: a case study of Ireland and the UK. In: WCTE 2021: world conference of timber engineering. Santiago.
- Oliveira, M., et al., 2013. Low cost construction: state of the art and prospects for using structure wood apartment buildings in Portugal.
- Penfield, P., et al., 2022. Assessing the adoption of cross laminated timber by architects and structural engineers within the United States. *Journal of Green Building* [online], 17 (1), 127–147. doi:10.3992/jgb.17.1.127.
- Riala, M., and Ilola, L., 2014. Multi-storey timber construction and bioeconomy—barriers and opportunities. *Scandinavian Journal of Forest Research*, 29 (4), 367–377.
- Rogers, E.M., 2010. *Diffusion of innovations*. 5th ed. New York: Simon and Schuster.
- Sandstrom-Mistry, K., et al., 2023. Comparing water quality valuation across probability and non-probability samples. *Applied Economic Perspectives and Policy*, 45 (2), 744–761. doi:10.1002/aep.13375.
- Schmidt, J., and Griffin, C.T., 2013. Barriers to the design and use of cross-laminated timber structures in high-rise multi-family housing in the United States. In: *Structures and architecture: new concepts, applications and challenges*. [online], 2225–2231. Available from: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85138333023&partnerID=40&md5=8cff61e7e4437c309353a4a5872ecc88>.
- Schuetze, T., 2018. Wood constructions for sustainable building renovation. *Advanced Materials Research*, 1150, 67–72. doi:10.4028/www.scientific.net/AMR.1150.67.
- Shirmohammadi, M., Leggate, W., and Redman, A., 2021. Effects of moisture ingress and egress on the performance and service life of mass timber products in buildings: a review. *Construction and Building Materials*, 290, 123176. doi:10.1016/j.conbuildmat.2021.123176.
- Svatoš-Ražnjević, H., Orozco, L., and Menges, A., 2022. Advanced timber construction industry: a review of 350 multi-storey timber projects from 2000–2021. *Buildings*, 12 (4), 404. doi:10.3390/buildings12040404.
- van der Westhuyzen, F.S., and Wium, J., 2021. A development cost comparison between a multi-storey mass timber and reinforced concrete building in South Africa. *Journal of the South African Institution of Civil Engineering* [online], 63 (4), 35–44. doi:10.17159/2309-8775/2021/V63N4A4.
- Wahlstrøm, S., et al., 2020. Experiences with CLT construction in Norway. *E3S Web of Conferences* [online], 172, 10008. doi:10.1051/e3sconf/202017210008.
- Wang, Z., et al., 2018. Influence of technical characteristics on the rolling shear properties of cross laminated timber by modified planar shear tests. *Maderas. Ciencia y tecnología*, 20 (3), 469–478. doi:10.4067/S0718-221X2018005031601.
- Wang, L., Toppinen, A., and Juslin, H., 2014. Use of wood in green building: a study of expert perspectives from the UK. *Journal of Cleaner Production*, 65, 350–361.
- Wiesner, F., et al., 2021. Structural capacity of one-way spanning large-scale cross-laminated timber slabs in standard and natural fires. *Fire Technology*, 57 (1), 291–311. doi:10.1007/s10694-020-01003-y.
- Zygomalas, I., et al., 2016. Quantification of the influence of life cycle parameters on the total environmental impact of steel-framed buildings. *International Journal of Sustainable Engineering*, 9 (5), 329–337.

## Appendices

### Appendix I. Search terms for the initial literature search of articles on the adoption of timber as a structural material in South Africa

Search Date	25 December 2024
Search Terms	("timber" OR "wood") AND ("construction" OR "building" OR "built environment") AND ("adopt*" OR "implement*" OR "utilis*" OR "uptake" OR "diffus*") AND ("barrier" OR "obstacle" OR "challenge" OR "constraint" OR "limit*") AND ("enabler" OR "facilitator" OR "driver" OR "catalyst" OR "incentive") AND "South Africa"
Databases (Results)	Scopus ( <a href="https://www.scopus-com.uplib.idm.oclc.org/results/results.uri?st1=%28%22timber%22+OR+%22wood%22%29+AND+%28%22construction%22+OR+%22building%22+OR+%22built+environment%22%29+AND+%28%22adopt*%22+OR+%22implement*%22+OR+%22utilis*%22+OR+%22uptake%22+OR+%22diffus*%22%29+AND+%28%22barrier%22+OR+%22obstacle%22+OR+%22challenge%22+OR+%22constraint%22+OR+%22limit*%29+AND+%28%22enabler%22+OR+%22facilitator%22+OR+%22driver%22+OR+%22catalyst%22+OR+%22incentive%22%29+AND+%22south+africa%22&amp;st2=&amp;s=TITLE-ABS-KEY%28%28+%22timber%22+OR+%22wood%22%29+AND+%28%22construction%22+OR+%22building%22+OR+%22built+environment%22%29+AND+%28%22adopt*%22+OR+%22implement*%22+OR+%22utilis*%22+OR+%22uptake%22+OR+%22diffus*%22+%29+AND+%28%22barrier%22+OR+%22obstacle%22+OR+%22challenge%22+OR+%22constraint%22+OR+%22limit*%22%29+AND+%28%22enabler%22+OR+%22facilitator%22+OR+%22driver%22+OR+%22catalyst%22+OR+%22incentive%22%29+AND+%22south+africa%22%29&amp;limit=10&amp;origin=searchbasic&amp;sort=plf-f&amp;src=s&amp;sot=b&amp;sdt=b&amp;sessionSearchId=a2e23291184ff096dfc283422a4be8f">https://www.scopus-com.uplib.idm.oclc.org/results/results.uri?st1=%28%22timber%22+OR+%22wood%22%29+AND+%28%22construction%22+OR+%22building%22+OR+%22built+environment%22%29+AND+%28%22adopt*%22+OR+%22implement*%22+OR+%22utilis*%22+OR+%22uptake%22+OR+%22diffus*%22%29+AND+%28%22barrier%22+OR+%22obstacle%22+OR+%22challenge%22+OR+%22constraint%22+OR+%22limit*%29+AND+%28%22enabler%22+OR+%22facilitator%22+OR+%22driver%22+OR+%22catalyst%22+OR+%22incentive%22%29+AND+%28%22south+africa%22&amp;st2=&amp;s=TITLE-ABS-KEY%28%28+%22timber%22+OR+%22wood%22%29+AND+%28%22construction%22+OR+%22building%22+OR+%22built+environment%22%29+AND+%28%22adopt*%22+OR+%22implement*%22+OR+%22utilis*%22+OR+%22uptake%22+OR+%22diffus*%22+%29+AND+%28%22barrier%22+OR+%22obstacle%22+OR+%22challenge%22+OR+%22constraint%22+OR+%22limit*%22%29+AND+%28%22enabler%22+OR+%22facilitator%22+OR+%22driver%22+OR+%22catalyst%22+OR+%22incentive%22%29+AND+%22south+africa%22%29&amp;limit=10&amp;origin=searchbasic&amp;sort=plf-f&amp;src=s&amp;sot=b&amp;sdt=b&amp;sessionSearchId=a2e23291184ff096dfc283422a4be8f</a> ): (1) Web of Science ( <a href="https://www-webofscience-com.uplib.idm.oclc.org/wos/woscc/basic-search">https://www-webofscience-com.uplib.idm.oclc.org/wos/woscc/basic-search</a> ): (0)

### Appendix II. Search results for the initial literature search of articles on the adoption of timber as a structural material in South Africa

Authors	Article Title	Year
Chimboganda, T., Broadhurst, J.L.	Investigating the potential use of fibre-rich plants to create multi-value chains for post-mining industrial development	2001