Fire, Fear & Wooden Futures?

An examination of the viability of a wooden architectural future following Grenfell Tower and changing public perceptions.

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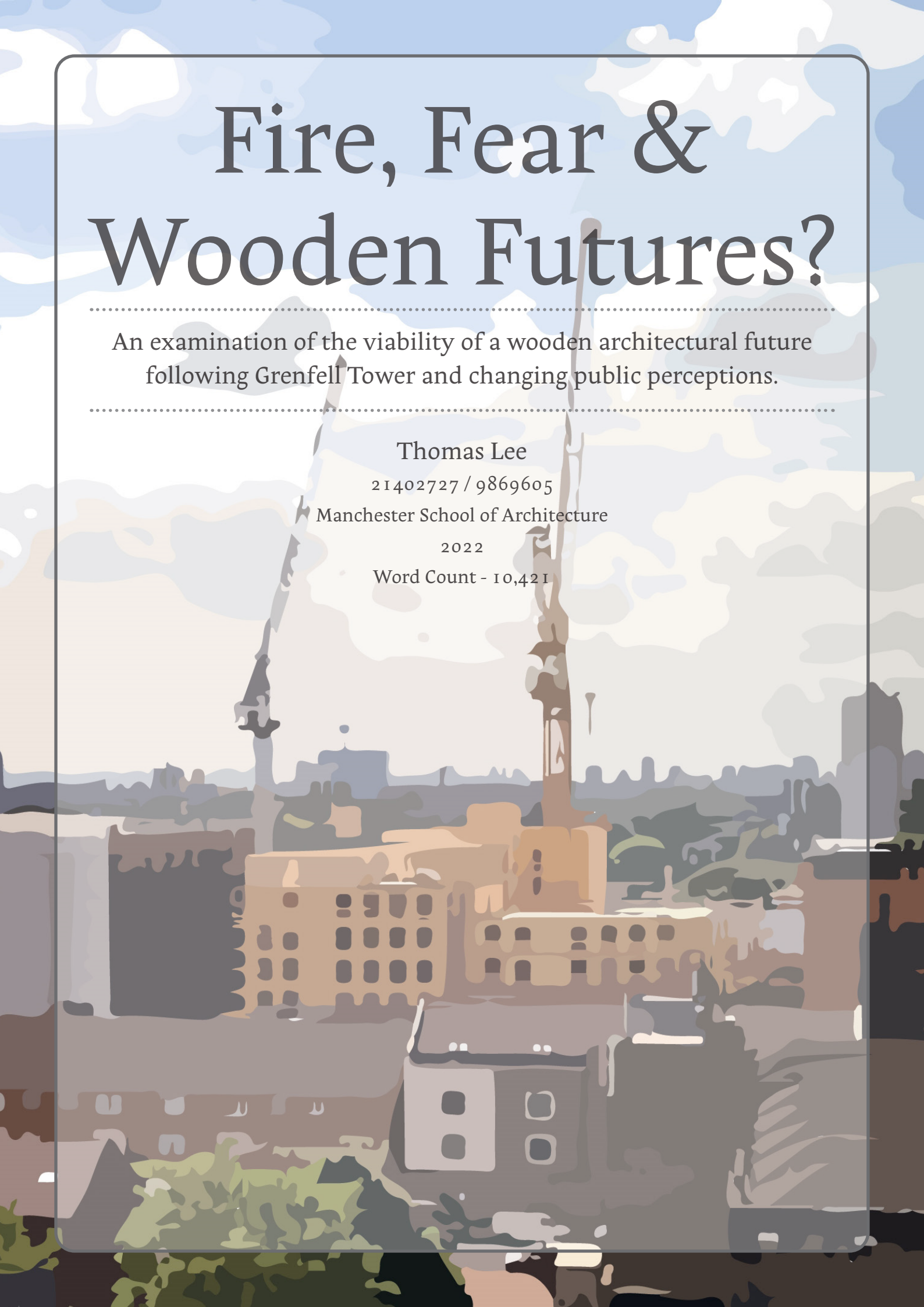
2022
Word Count - 10,421



Acknowledgements

I would like to take this opportunity to express my gratitude to all who helped me conduct this investigation: Firstly, thank you to my supervisor Demetra Kourri for offering useful feedback and guidance throughout. It was much appreciated.

Thank you to all who gave their time to participate in interviews. Your insight was invaluable and helped make this investigation more well informed and thorough.

Last but not least, thank you to my family for their encouragement and support throughout my studies, with a special mention to my Grandfather who we sadly lost during the course of this research. Your reassurances of my abilities were greatly appreciated, and you will be missed.

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Abstract

With increasing pressure being placed on the construction industry to transition to more sustainable and environmentally conscious methods of construction, engineered timber as a potential replacement has become an animated region of discourse within architecture. Research performed over the past decade has however exposed the extent of concern and hesitance associated with the material in the public domain.

This study aims to determine how public perception is able to influence the construction industry, and how any influence present will impact the future viability and deployment of the technology. This question will be situated in the context of Grenfell Tower as a significant event to additionally determine if there was a change in perception as a result. Thorough analysis of prior empirical studies, underlying perception in both public and professional domains prior to Grenfell Tower will be determined while additionally examining barriers to adoption which the technology faces. To provide additional primary data for the perception following Grenfell Tower, the methods proposed by Yaneva in 'mapping controversies in architecture' will be used to pragmatically evaluate and present the public perception displayed on social media. Industry practitioners will be interviewed to provide insight concerning changes observed within the construction industry as a result of Grenfell Tower. The investigation demonstrated a perception characterised by distrust and hesitance both before and after Grenfell tower, and while there has not been significant movement in public perception, the importance which the public place on sustainability has grown. Professional practices have developed social value policies, which are revealed to be a powerful mechanism to gradually introduce change in a way which does not compromise financially viable practice, illuminating a sense of optimism when considering the roll-out of more sustainable and environmentally conscious design methods.

Glossary of Terms

ACM – Aluminium Composite Material

ADB – Approved Document B (Fire Safety), Building Regulations

AI – Artificial Intelligence

ARB – Architects Registration Board

BREEAM – Building Research Establishment Environmental Assessment Method; a method used to assess sustainability in a construction project

BSI – British Standards Institute

BS9999:2017 – British Standards: Code of practice for fire safety in the design, management, and use of buildings

CLT – Cross Laminated Timber

CPD – Continuing Professional Development

CONIAC – Construction Industry Advisory Committee

Glu-Lam – Glue Laminated Timber

G Value – Rating of the amount of solar radiation which is able to pass through a window

HSE – Health & Safety Executive

IEA – International Energy Agency

IMS – Information Management System

MTC - Mass Timber Construction

MHCLG – Ministry of Housing, Communities and Local Government

RIBA – Royal Institute of British Architects

RSI – Repetitive Strain Injury

R Value – Unit of measurement for the capacity of an insulating material to resist heat flow

STS – Science & Technology Studies

SCOT – Social Construction of Technology

TOMS Framework – Themes, Outcomes and Measures. A tool used to evaluate social value

U Value – Unit of measurement for the rate of thermal transmittance through a structure

UN - The United Nations

Key Words

Public Perception | Grenfell Tower | Engineered timber | Social Value | Financial Sensibility | Future Viability

Introduction

The Grenfell Tower incident is an event which has galvanised the UK public and gained significant attention throughout the wider construction industry. Originally constructed in 1974, the tower situated in the London Borough of Kensington and Chelsea provided 129 flats of social housing within its 24 stories. Refurbishment was carried out on the structure and completed in 2016 which included "*new exterior cladding, replacement windows, heating systems and remodelling of the bottom four floors*" (Potton, 2020, p4). Following the refurbishment, on the 14th of June 2017, a faulty refrigerator ignited on the fourth floor of the tower. The refrigerator positioned close to a window, passed the fire through to the buildings external cladding which spread horizontally and vertically at an unprecedented rate. This rate of fire spread was later attributed to the ACM (Aluminium composite material) cladding product, containing "*highly combustible polyethylene polymer filler" a material which "is expected to release a large amount of energy during combustion*" (BBC, Grenfell tower: What Happened, 2019).

Following the gravity of this tragedy, public discourse became reanimated, leading to extensive investigation and inquiry taking place throughout multiple disciplines, subsequently resulting in reform of building practices, regulations, and policy, in an effort to prevent an incident of this nature from occurring again (Smith & Woodcraft, 2020, P1). Specifically, as stated by Potton, amendments were made to Approved document B1 (Fire Safety – Dwellings) of building regulations as a direct consequence (Potton, 2020, p9). The resultant was a comprehensive ban on the use of combustible materials in the external wall of buildings exceeding 18m (MHCLG, 2018, p2).

Grenfell Tower as a landmark event acts as a medium through which an understanding of the relationship between public perception and building practices can be determined. Once this relationship is understood, it becomes possible to examine the affect public perception can have on technological development and sustainability within the construction industry, an important consideration when discussing the potential viability of new sustainable construction technologies such as engineered timber products and CLT.

Increasing global initiatives concerned with climatic impact and reduction of emissions have become ubiquitous, elevating the pressure on the architecture and construction industries to reform their common practices, and employ new more environmentally conscious solutions. This has however remained a controversial issue within architecture practice with authors stating "*there has been a lack of interest in developing construction technology - a serious problem for our [architecture] field*" (Waugh Thistleton, 2018a, p5). Many proponents have advocated for the use of engineered timber products, including Waugh Thistleton, however in light of the Grenfell Tower incident, the validity of lower carbon alternatives have been brought into recursive discourse. Smith and Woodcraft describe these 'failure events' as "*powerful, constituting effects: they take root and circulate in ways that cross and recross ethnographic and analytic domains*" (Smith & Woodcraft, 2020, p2).

Grenfell tower is an event which remains at the forefront of the public consciousness, and it would therefore seem prudent to further understand the perception presently held, in the interest of establishing the driving forces behind the resistance associated with implementation of emerging building technologies including CLT, Glu-Lam, Wood-Fibre Insulation and more.

Establishing the pre-existing public perception demonstrated in scholarly studies prior to Grenfell Tower will be the initial focus of the literature review within this investigation. Subsequent analysis will be carried out to determine perception post Grenfell tower, which when considered supplementary to consultation with industry practitioners, it is hoped that the collected information will contribute to generating a holistic understanding of any impediments currently facing construction technologies, and allow for deductions to be made.
The investigation is chronologically structured into separate empirical chapters, each with a specific area of focus, progressing the narrative of investigation.

The state of Changing Perception

Objective - Identify the perceptions demonstrated by the actors Pre & Post Grenfell, allowing the determination of the range of impacts which Grenfell tower as a controversial event shaped collective opinion.

Practice, Perception & Influence

Objective – Examine the extent to which public perception & legislation changes affected the complex socio-technical, political, economic and moral dimensions of modern professional practice when considering sustainable timber construction methods.

Future trajectory

Objective – Describe and evaluate the future viability of emerging sustainable engineered timber technologies, following analysis of public and professional views when situated in a post Grenfell context.

Chapter 1 - Literature review

Introduction

To understand the impact which the Grenfell Tower incident had on public perception, we must first develop an understanding of the preconceptions held prior to the event. For this reason, existing literature will be examined to determine prior approaches used to assess public perception by previous scholars. In examination, it becomes evident that the populations surveyed in the empirical studies remain hesitant when consulted about the use of timber products in construction. Additionally, the collated opinions of these surveyed groups can be divided into two distinct categories, hard and soft consideration factors. There are many elements which influence these views and will be discussed further in the primary section of this review.
With the prevailing opinions of the public in mind, it also becomes important to then understand the views held by industry professionals, primarily to determine if there is any disparity in opinion compared to the public, but subsequently as understanding views held in professional circles prior to Grenfell will allow direct comparison to currently held views voiced by selected practitioners.

The literature review will conclude with presentation and evaluation of proposed conceptual models. The validity of these frameworks can be tested through application to the previously analysed literature, and it is hoped that they can be utilised to define a relationship between public perception and the construction industry. Understanding this relationship will allow observations to be formulated and key themes to be concisely presented in the context of this investigation.

1.1 – Public Perception

The relation between consumer attitudes and timber in construction has been thoroughly investigated and become well established; a survey performed by Gold and Rubik (2008) determined that within the German public, there was a general prejudice towards timber as a construction material, due to the perceived deficiency in fire resistance, durability, and stability. These were determined to be critical criteria when choosing a construction mode and "*persists in the minds of consumers*" (Gold & Rubrik, 2008, p1). However, it was also established that 'soft' criteria such as well-being, aesthetics and eco-friendliness were attributed to the material, and received vastly positive sentiment. (Gold & Rubrik, 2008, p4).

Due to the rapidly changing urban environment, increasing favour and demand for sustainable building practices, researchers and practitioners are becoming increasingly interested in the viability and usage of timber within standard building practices (Waugh Thistleton, 2018a). This has resulted in many authors from multiple countries surveying the public opinion and current perception of timber products in construction.

This rapid development in material technology introduces a shortcoming of the research provided by Gold and Rubik. Engineered timber products are a relatively recent material development as stated in the 2019 Publication by ARUP - 'Rethinking Timber Buildings'

> "The timber industry has been enjoying significant growth in the last decade, primarily due to the increase in mass timber products such as Cross Laminated Timber, Glu-lam and Laminated Veneer Lumber" (ARUP, 2019, p5)

With the majority of developments in the field occurring in the previous 10 years, the study conducted by Gold & Rubik in 2008 neglects to include any reference to engineered timber products, possibly due to lack of prevalence. This may have contributed to the overwhelming hesitance and concern seen in the study. Later investigations by additional authors (Larasatie et al, 2018; Evison et al, 2018; Petruch & Walcher, 2020), do however confirm the validity of their research, and demonstrate that the hesitance towards timber as a major building material is still present. These additional studies show that this trend is present in a diverse number of geographic regions.

Kremer and Symmons (2016) build upon the work of Gold & Rubik with a similar survey 'Overcoming psychological barriers to widespread acceptance of Mass Timber Construction in Australia'. Their study produced results vastly alike with those collected in prior studies, observing "*often lacking and prejudicial perceptions of MTC present*" (Kremer & Symmons, 2016, p1) within the public eye. As stated by Spink (2010) in the publication, 'Information Behaviour, an evolutionary instinct' preconceptions arise from what behavioural science calls 'instincts' and are "generally understood as the innate part of behaviour that emerges without any training or education in humans" (Spink, 2010, p35).

Kremer & Symmons begin to address this statement by Spink and identify an area not explored in the research performed by Gold & Rubik. They neglected to collect data regarding the source of knowledge which contributed to the forming of their opinion. Kremer & Symmons collected data surrounding the various sources of knowledge for participants that indicated prior awareness in the topic area. This indicated that only 20% (57 out of 281 participants) had prior knowledge in the topic area. The sources identified by the respondents are detailed in the extract below.

> "television shows such as Grand Designs (United Kingdom), within the workplace (within the construction industry), working on CLT projects, via various media channels (including social media), through university research studies, and via industry conferences/exhibitions." (Kremer & Symmons, 2016, p16)

The majority of information sources cited above are related to the construction industry, with only one reference being made to a widely available source of information (televised entertainment).

It alludes to a lack of information and media available for education and awareness in public circulation, and therefore begins to indicate why there is such a predominant hesitance towards the usage of timber in construction, as demonstrated in previous empirical studies, from a different geographic & demographic region. Methods of addressing the lack of general public awareness were also put forward in Kremer & Symmons paper such as; "educating concerned consumers, age appropriate targeted marketing messages, info-graphics, videos, walk throughs and advertising" (Kremer & Symmons, 2016, p25-26). These are all valid methods of tackling public perception, however they do not address the level of public receptiveness to any information provided.

1.2 – Professional Perception

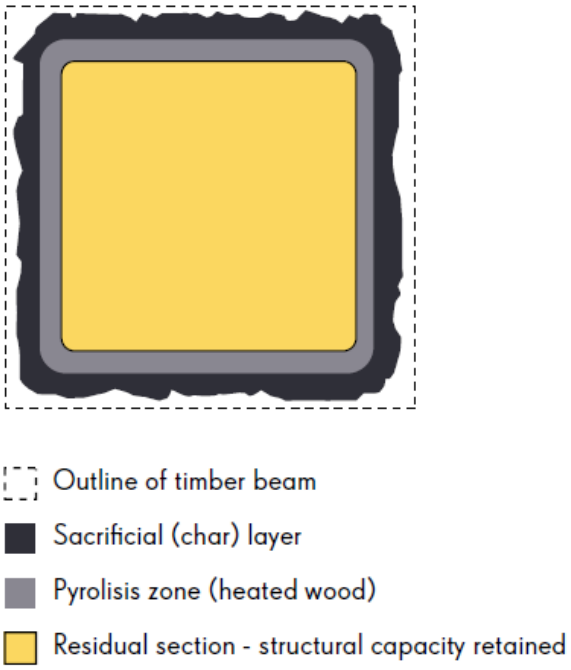
While the discussion and use of timber construction in a professional environment is not uncommon, there is frequently a dichotomy in opinion. Many practitioners recurrently state the benefits to mainstream adoption of engineered timber products however, they are frequently met with considerable inertia impeding adoption. (Waugh Thistleton, 2018a). Kremer & Symmons exhibit first-hand accounts by industry experts within their study speaking to the benefits of MTC, but also the potential reasons for concern within the construction industry.

One particularly poignant comment is provided by a material supplier suggesting that uncertainty from a singular party within a project can incur significant implications to cost. (Kremer & Symmons, 2016, p30). Initially this account could imply that an end consumer would be subject to this increased cost, harming the material perception, a sentiment mirrored by Waugh Thistleton. They state lack of material awareness among cost consultants could be attributed to the higher project cost, as the consultant is likely to assign an unrealistic base cost to the construction, compared with a consultant familiar with the material requirements and potential benefits (Waugh Thistleton, 2018a, p45). This concurrence would suggest hesitance towards adoption to also be present in professionals, however not as widespread as within the public eye.

When examining the reasons behind hesitance in Kremer & Symmons' and Gold & Rubik's studies, fire resistance and performance is among the primary concerns in both public and professional sectors. 'Inherent fire resistance' however is a topic discussed at length in multiple publications (Hough, 2019, p66; Structural Timber Association, 2015, p5; Waugh Thistleton, 2018a, P35; TRADA, 2019, p1).

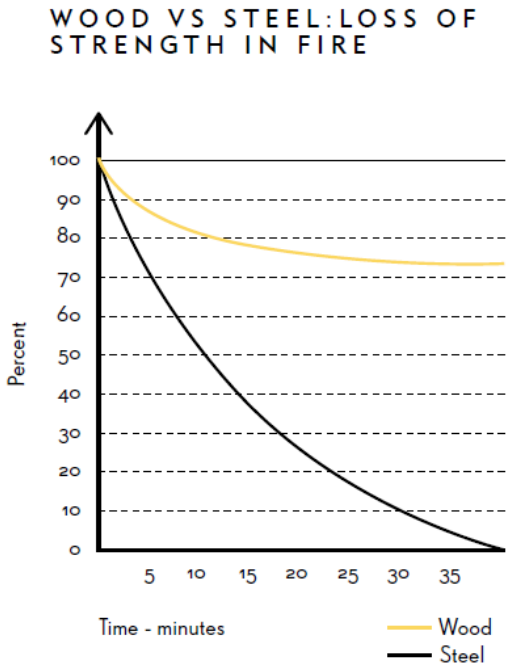
Additionally, examining different forms of literature comparatively uncovers a topic in which there is a disparity in knowledge level between public and professionals when concerning fire performance. This is not a surprising difference as professionals within the construction industry would be expected to retain a higher level of knowledge surrounding the subject however, addressing this disparity may be influential in public perception. Within both Gold & Rubik and Kremer & Symmons studies, it has been exhibited that the public display concern in relation to the fire safety performance of the material however, 'inherent fire resistance' of engineered timber products is a topic discussed at length in professional publications (Hough, 2019, p66; Structural Timber Association, 2015, p5; Waugh Thistleton, 2018a, P35; TRADA, 2019, p1).

This is a disparity realised by Waugh Thistleton, "*As wood is combustible it leads to an inevitable concern about the fire performance of timber buildings. However, it is important to understand that all materials have their limitations when exposed to a fire*" (Waugh Thistleton, 2018a, p62). Waugh Thistleton goes further to exemplify the stated fire performance of timber (CLT), and also compare performance against steel using diagrams (Below).



CLT Char Pattern

Firgure 1. (Source: Waugh Thistleton. 2018a. '100 projects UK CLT' p64)



CLT vs Steel Strength Over Time

Firgure 2. (Source: Waugh Thistleton. 2018a. '100 projects UK CLT' p62)

Following the low level of awareness of the fire performance of engineered timber products, it could be assumed that there would be a similarly lacking awareness of the mainstream practice of fire rating steel construction among the general populous. "*The use of intumescent coatings plays an important role in the fire protection of structural element*" (Mesquita et al, 2007, p1) and has become a standardised practice for the design of fire safe steel structures. The mechanism through which intumescent coatings works is "*via the formation of uniform multicellular char layer*" (Beh et al, 2020, p1), protecting the core structural material. This is vastly similar to the mechanism through which CLT achieves its fire rating, however, the material accomplishes this without the need for additional coatings. This level of material specific knowledge may be beyond reasonable expectation in the public domain, and as a result was omitted from prior studies deliberately. It may however be worth investigating this further through discussion with industry professionals.

The statements collected by Kremer & Symmons display various indications that outdated perceptions and lacking awareness of recent technologies persist throughout various regions of construction industry, and therefore the presence of obduracy within the construction industry. This will be investigated further in the later empirical chapters.

1.2 – Conceptual Validation

To begin to discuss how public perception can have an influence on the architecture and construction industries, it is necessary to establish a conceptual framework through which to understand the socio-political dynamics involved. The author Anique Hommels, a key author in STS (Science and Technology Studies) introduces the concept of Socio-technical Obduracy stating that obduracy is 'displaying resistance to change' (Hommels, 2005, p329). This theory is presented in three conceptual models: Frames, Embeddedness and Persistent Traditions, each examining a different scale of obduracy. Through the application of the models presented by Hommels to the prior examined studies, the validity of the models can be determined, and thus serve as a valid conceptual basis under which further analysis can be performed.

The most explicit model proposed is that of 'Persistent Traditions' which suggests that long term shared views influence the development of technology over time. This model implies that there is a tendency to prefer the familiar, and are influenced by the previous events, a sentiment which is exhibited by multiple statements given within Kremer & Symmons investigation,

Supplier - "*I think the biggest hindrance is the unknown. People do not have enough understanding or knowledge about it [MTC]*" (Kremer & Symmons, 2016, p30).

Insurance Broker - "*The insurance industry rates things based on historical data*" (Kremer & Symmons, 2016, p30)

These statement when situated conceptually indicate there may be a relationship between the theory of obduracy and the construction industry, with familiarity and historical events exerting significant influence over material selection.

The Embeddedness model may additionally provide evidence to the presence of obduracy within this industry. The model explains that technological artefacts are not analysed in isolation, but as part of a socio-technical system. This proposition suggests that engineered timber technology would be compared to the currently adopted industry standard materials, for example concrete and steel. When applied to a practical example, a statement provided by Kremer & Symmons indicates the insurance sector operates conservatively as they "*tend to sit back and wait and see what things do" – Property underwriter*" (Kremer & Symmons, 2016, p30). This hesitance displayed when conceptually evaluated also provides indication of an established relationship between obduracy and the many parties involved in the construction industry.

As a result of the correlation between the prior studies and the chosen conceptual framework, the model presented by Hommels can be corroborated and serve as a valid conceptual understanding through which to further examine public perception and its impacts.

Chapter 2 - Methodology

Methodologically, this investigation will adopt the approach proposed by Albena Yaneva in 'mapping controversies in architecture', to assist in analysing and interpreting a complex and multifaceted issue from a pragmatic context. It will allow the event to be examined not based on reductive factors such as social, economic, political, and historic, but as a network influenced by actors and their agency. This will allow the architecture involved in this investigation to be understood at a holistic level (Yaneva, 2012).

As an author based in Social Construction of Technology, Hommels serves as an appropriate theorist to incorporate as their focus lies primarily in how social perceptions and their networks affect building practices, with the affect of materials and their attributes forming a secondary role (Hommels, 2005). The nature of material forms a central aspect of this investigation, and while the concept of obduracy established by Hommels is helpful to understand the evident resistance to change, combining this model with 'mapping controversies' allows the investigation to rely less on a hierarchical model of social relations and focuses instead on understanding the role of the material and its influence on actors and their exchanges.

The research performed will be exemplified though a mixed method study, employing both quantitative and qualitative sources of information. The former will consist of systematic examination of existing empirical studies, to establish the public perception of timber in construction prior to the Grenfell Tower Incident. The scholarly articles and literature cited have been obtained from academic databases and institutions such as JSTOR, EBSCO, Elselvier and university libraries. The credibility of sources selected have been determined through identification of studies which have a high citation count, cross citation, and comparison to relevant conceptual frameworks. To establish the validity of the conceptual models employed within this investigation, the proposed models have been directly compared to the results of the studies performed in the examined peer reviewed literature to determine to what extent the model applies. Determination of the credibility of conceptual models, and utilised literature allows for a generalised understanding of the state of public perception in multiple geographic and demographic regions to be formulated.

To provide context for the investigation, Grenfell Tower will be established as a controversial event. An ethnographic study will be constructed from collections of comments on special media in response to articles, news headlines and reports relating to wooden or timber construction. Word-cloud networks and event timelines will be produced to allow both the frequency of key opinions to be visualised, but also the tracing of events chronologically, producing a map of the controversy. The maps created were produced through the use of Infra-Nodus, an online data analytics tool which allows network data to be visualised and statistically analysed using an AI algorithm. The tool is able to identify influential nodes, determine associations within the network and identify sentiment through natural language processing.

A factor which will be considered when formulating conclusions based on data collected from social media is the inaccuracy of representation which this introduces. Views expressed by respondents on social media are not necessarily representative of wider public opinion as the respondents who engage with social media are more likely to hold polarising views and voice their opinion on these platforms. It must also be considered that the motivation behind a news article or story may not have only been to disseminate information, but to also provoke response. This will be a key consideration when answering the research question relating to the portrayal of timber construction in the media influencing people and projects.

To alleviate the bias introduced, any conclusion drawn from social data will be combined and compared with prior examined research, and primary data collected from interview of industry professionals. This will contribute to presenting a more realistic understanding of the public perception of timber in construction, both prior and trailing the Grenfell Tower incident.

Primary qualitative data will be utilised in the form of interviews with industry professionals and practitioners. This will serve the purpose of establishing the changes they have experienced within the construction industry following the Grenfell Tower incident. Due to the controversial topic & nature of the investigation, the study participants have been kept anonymous upon request. The direct responses will be formulated using a combination of individual observation, and previously established perceptions to draw conclusions as to the extent which public perception following Grenfell have changed and influenced building practices.

Interviewees

Architect – Name Anonymous. Extensive experience within a large architecture firm, operating in multiple architectural sectors throughout the UK

HSE Officer – Name Anonymous. 15 Years+ experience as Health and Safety Inspector and officer working at both a Local Authority and County Council Level.

Interview participants were chosen on the basis that they provide a ranging breadth of experience within the construction industry. It is important to note that due to logistical difficulties, the desired range of interviewees was not performed. As a method of reparation, the interviewee unable to participate was contacted by message to allow their input to still be collected. Additionally, as professional comments were recorded within Kremer & Symmons investigation, these secondary sources will be used to corroborate any findings.

Finally, the future trajectory of timber in construction will be probed using a case study of Dalston Works to provide dialogue as to the future viability of the emergent timber technologies.

Chapter 3 – State of changing perceptions

Introduction

To establish the evolution of public perception following the Grenfell Tower incident, an ethnographic study has been constructed from a collection of articles and news reports concerning timber methods of construction. Comments in reply to the articles provide insight into the kind of response members of the public are having to the information presented. The opinions voiced in these comments allow 2 types of analysis to be performed. Initially analysis of the comments on each article allows for the perception to be determined. Secondly through statistical analysis, sentiment and receptiveness to the presented information can be measured. This is what Yaneva refers to as 'second degree objectivity', which will be examined through production of a quantifiable data-based metric. When chronologically mapped, interpretation of this data can be performed, and conclusions be drawn.

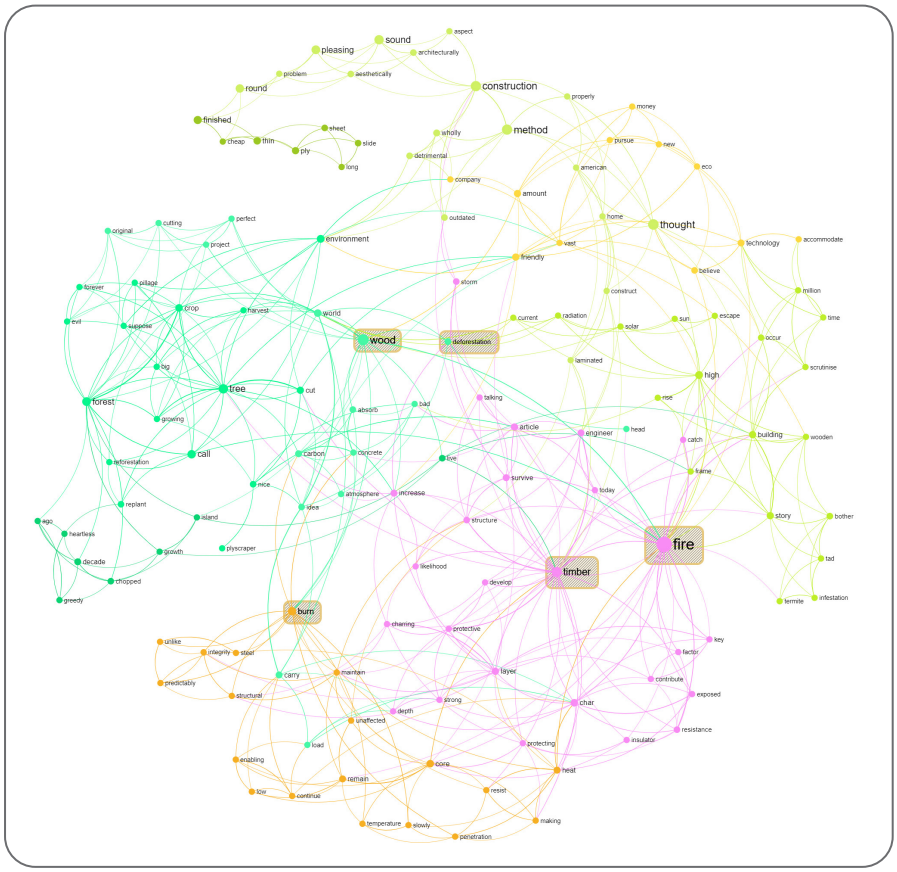
To conclude this section, I will attempt to produce a unified determination of the current state of public perception in relation to timber construction, and the effect which previous historical incidents, more specifically Grenfell Tower has influenced this perception.

3.1 Pre-Grenfell Perception

To provide initial data for the state of perception before Grenfell, the mapping method developed by Yaneva was applied which "*enables us to describe the successive stages in the production of architectural knowledge, artefacts, buildings and urban plans*" (Yaneva, 2012, p72). The first article to which this method was applied was titled 'Is the Ply-scraper the future of flat-pack cities around the world?', published by The Guardian on the 4th October 2014, pre-dating Grenfell Tower by 3 years.

The article initially explores the evolution of the skyscraper and the technologies which allowed this development, "lightweight steel frame relieved a structure of its heavy masonry shackles, enabling it to soar to new heights" (Cathcart-Keays, 2014). The narrative subsequently explores increasing CO_2 emissions associated with the construction industry and includes specific reference to 'engineered timber' as a product which "*offers the prospect of a new era of eco-friendly 'plyscrapers*'" (Cathcart-Keays, 2014). The article concludes with statements from various peers within the construction industry advocating for the benefits of the material, accompanied by example case study projects. Overall, the article speaks positively of the future prospects associated with timber construction, however this sentiment is not reflected by the public. Determined through comments left on the article, it is possible to form associations through the production of word maps, forming patterns remaining normally unseen.

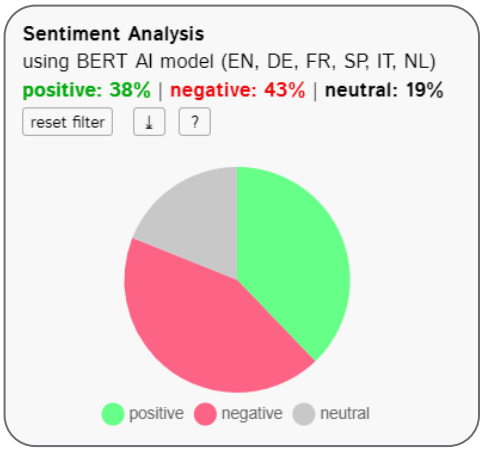
2014 Perception Map



The Guardian - 4th October 2014

Figure 3a. (Source: Author, created using InfraNodus)

Comment Sentiment Analysis



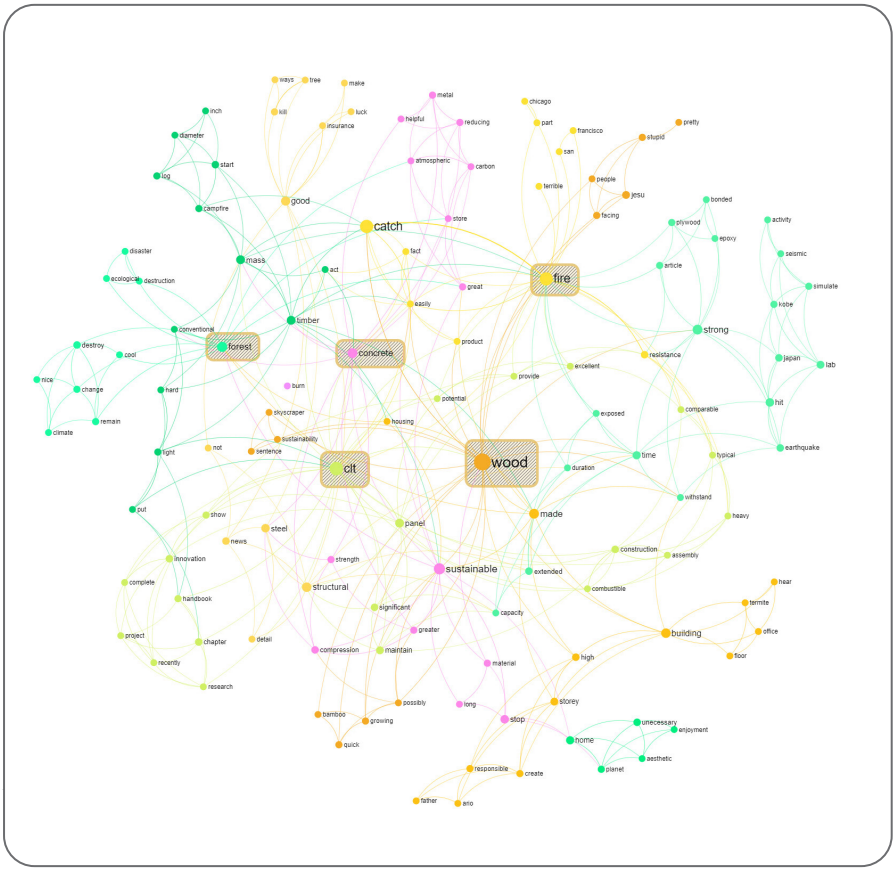
The Guardian - 4th October 2014

Figure 3b. (Source: Author, created using InfraNodus)

Figure 3a depicts the prevalence and frequency of words seen within the comments. The size of the word within the web directly corresponds to its frequency of appearance within the comments. The lines connecting nodes indicate words which appear together within comments, and the colour indicates topic groups of these words. This figure indicates the most common word throughout the comments is 'fire'. Other common words include wood, burn, environment and deforestation. This shows regardless of the sentiment of the original article, the members which commented on the article continue to display concern with regard to fire safety, and sustainability, both criteria outlined in prior research as major concerns (Gold & Rubik, 2008; Kremer & Symmons 2016; Larasatie et al 2018; Evison et al 2018). Additionally, statistical analysis of the map (Figure 3b) is able to determine the sentiment of all comments as a percentage, more clearly indicating collective sentiment. The majority of the opinions voiced within the article are negative, with 43% of all comments expressing some form of concern, while positive comments make up the minority at 23%.

A second article pre-dating Grenfell which was also mapped was produced by Wired.com on the 30th May 2017. This article with the title 'Get ready for skyscrapers made of wood. (Yes, wood)' initially provides a brief history of the John Hancock centre in Chicago and the Sears Tower, for the purpose of establishing the volume of concrete and steel required to build on that scale. This is followed by establishing the capabilities of engineered timber and concluding with a remark that while promising, still requires significant testing and development. (Stinson, 2017). While the article frames the material positively and opportunistically, a similarly sceptical pattern is seen in the mapping of the associated opinion as seen with The Guardian article from 3 years prior.

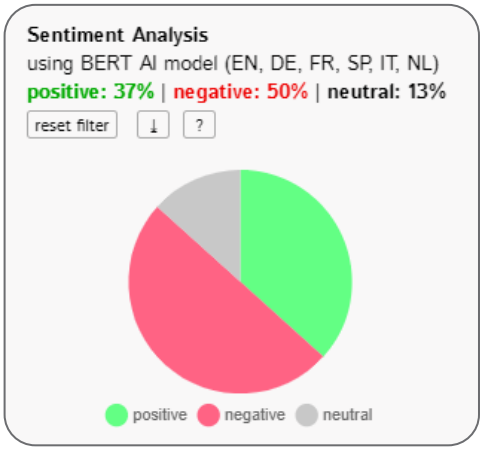
2017 Perception Map



Wired.com - 30th May 2017

Figure 4a. (Source: Author, created using InfraNodus)

Comment Sentiment Analysis



Wired.com - 30th May 2017

Figure 4b. (Source: Author, created using InfraNodus)

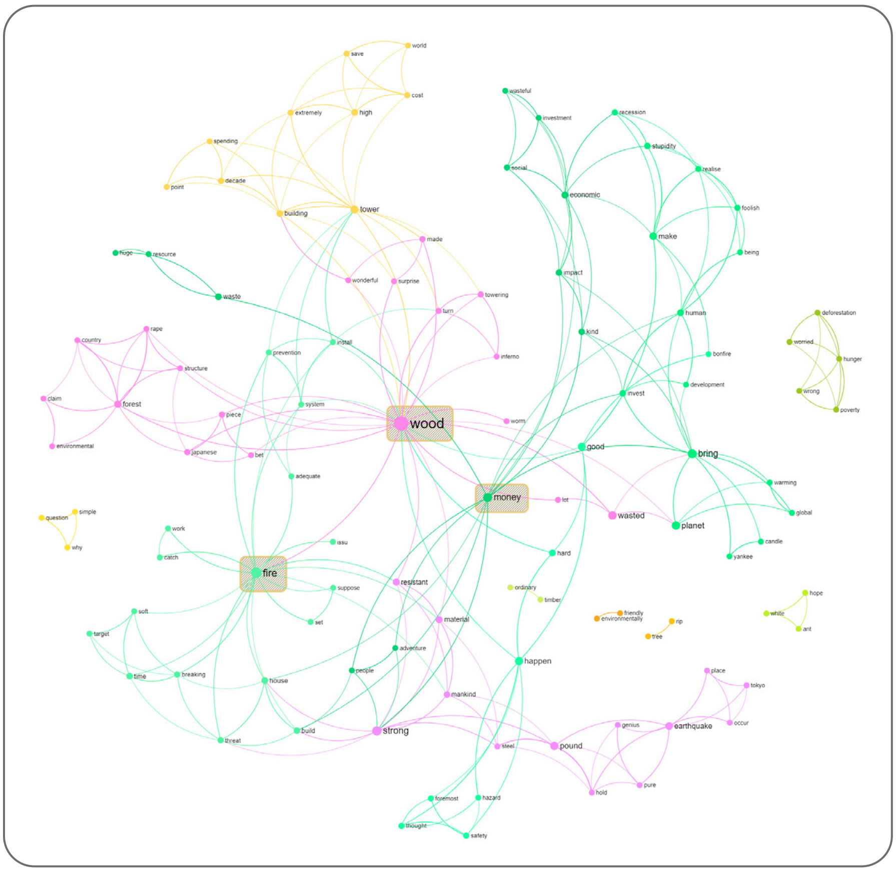
The map produced from the Wired article comments indicates the most common word used throughout is wood, closely followed by fire, CLT, sustainable and concrete. This is vastly alike with the 2014 map and displays concern again with recurrent focus on fire safety and the environment. The statistical analysis accompanying the map indicates that the collective statement is 50% negative and 37% positive. The disparity between positive and negative sentiment here is smaller than previously however, still majority negative. The possible reasons behind this shift in polarisation remains difficult to determine, however a possible explanation may lie in the amount of time between the articles. As stated by scholars, engineered timber construction is a recently emerging development. Between 2014 and 2017, there may have been enough material technology progression that it has been increasingly more covered by the media, and as a result further proliferated throughout the public domain. The broad concern evident, and the corroboration provided by the prior empirical studies provides a representation of public perception which encapsulates an existing distrust of timber construction technology prior to Grenfell Tower.

3.2 Post Grenfell Perception

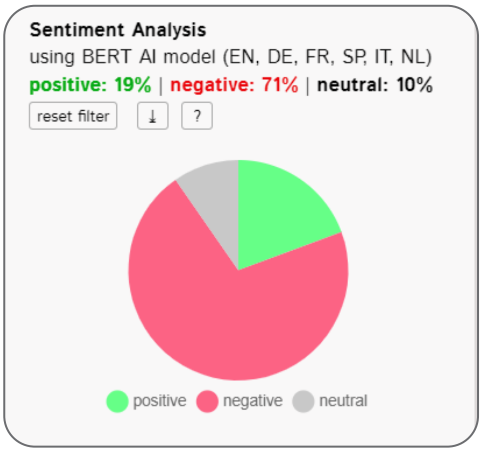
To ascertain the impact Grenfell Tower as a controversial event had on the UK public perception of timber construction methods, the same process will be used to map perception observed in relation to articles and news stories surrounding timber construction.

The first article used to analyse post Grenfell perception was a report by CCN international, dated 20th February 2018. The article titled 'Tokyo to Build World's Tallest Timber Tower' is a speculative report presenting proposed imagery, initial project statistics and discusses the hybrid structural approach and earthquake resistance. It proceeds to discuss engineered timbers rising prevalence, citing the Oakwood Timber tower proposed by PLP Architects. The project was put forward by the UK firm in 2016 (Pre-Grenfell Tower) as a research proposal to serve as a provocative ideal and promote "*entirely new experiences of the city in the 21st century*" (PLP, 2016). Following this, the article provides a section concerning wood as a fire hazard, stating that the material can be engineered to provide a required fire resistance, finally concluding with prose on sustainability (Marsh, 2018). The article ultimately provides an effective analytical discussion about future implementation of timber construction methods in a high-rise typology and can be characterised as enthusiastic.

2018 Perception Map



Comment Sentiment Analysis



CNN - 18th February 2018

Figure 5b. (Source: Author, created using InfraNodus)

CNN - 18th February 2018

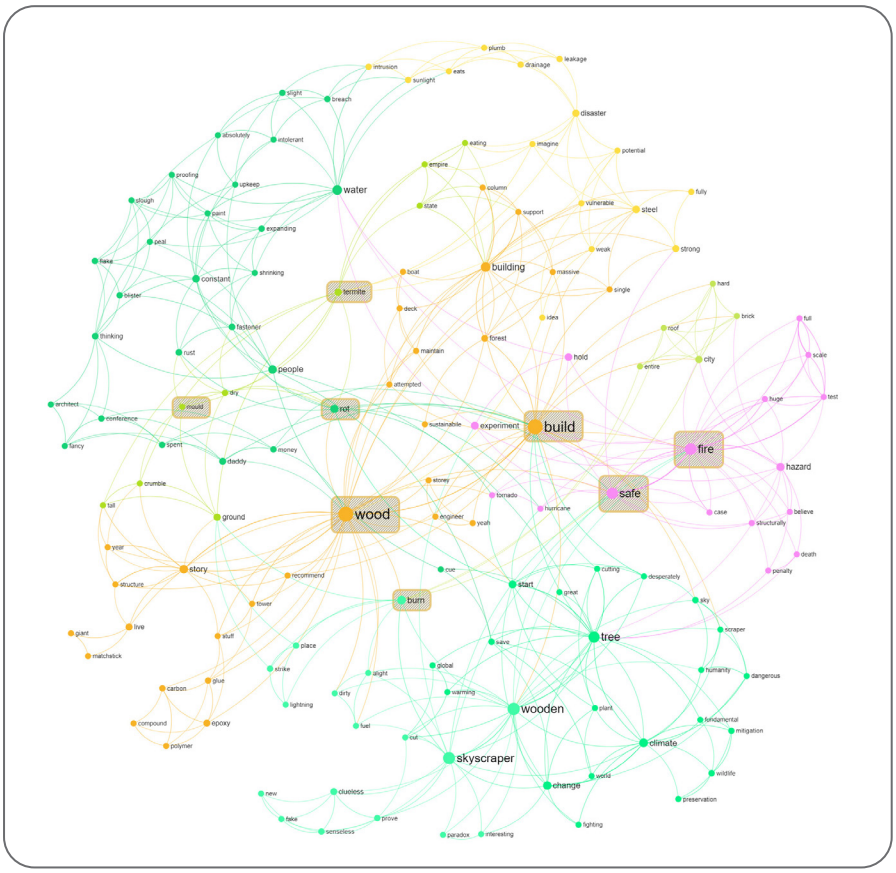
Figure 5a. (Source: Author, created using InfraNodus)

The resulting response observed on social media however was largely disparate. The map produced from comments in response to the article on social media show words such as wooden, fire and burn to be the most frequently occurring while also directly connected, indicative of association.

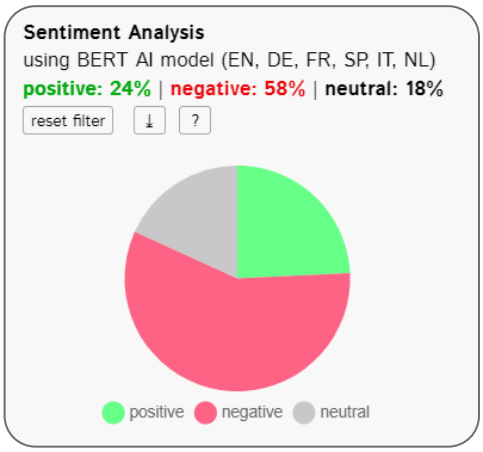
This is also reflected in the word grouping with wood + burn being within the same topic area. Furthermore, when statistically analysed the sentiment of the article response is indicated to be 71% negative. With such a large majority sentiment, the response to the article could be described as condemnatory, regardless of the content of the original article. This is a general trend for multiple articles spanning the following 4 years.

The CNN article published on the 14th February 2020 holding a title similarly optimistic in nature 'Has the wooden skyscraper revolution finally arrived?' receives a large amount of negative association between the keywords Wood, Burn, Fire, and Safe, and as a result receives a 58% negative sentiment towards the article content.

2020 Perception Map



Comment Sentiment Analysis



CNN - 14th February 2020

Figure 6b. (Source: Author, created using InfraNodus)

CNN - 14th February 2020

Figure 6a. (Source: Author, created using InfraNodus)

While vastly similar in overall sentiment to previous articles demonstrating predominant distrust, there is a slight difference in the comments on this article. The concern displayed appears to be based largely on instinctual knowledge and historical events such as the 'Great fire of London' and 'The Great Chicago Fire'. Concerns of this nature were previously observed and stated in the scholarly literature analysed, with the concerns evident being considered 'Hard Factors' (Gold & Rubik, 2008; Kremer & Symmons, 2016). Additionally, comments exhibited can be directly attributed to conceptual models of obduracy presented by Hommels. The persistent traditions model assigns direct relation between obduracy and the tendency to prefer the familiar, while being influenced by the previous events. The comments citing the Great fire of London - 1666, and the Great Chicago Fire – 1871 indicate a direct association present between historic events and concern & distrust of technology presented within the articles.

The quote provided by Gill Kernick "*Catastrophic events have the power to be disruptive*" (Kernick, 2021, p1) is evidently true and these observations provide further evidence for obduracy within the public domain remaining present. Of the 8 articles statistically analysed, all 8 received a majority negative sentiment when observing the comments given by the public in reply. This will be further explored in the following section which presents all of the articles analysed graphically and chronologically.

3.3 Mapping Perception over time

This section will further investigate the public perception observed by presenting the data chronologically to allow further insight into the development of the controversy. Below is a graphic which was produced using the entirety of data collected on public perception during this investigation.

As shown in figure 4, the two articles analysed which pre-date Grenfell tower, both share optimistic and positive headlines, with the first headline posing timber as possible future building material, whereas the second frames the material as more of a future certainty. Both articles receive a majority negative sentiment, at 45% and 50% respectively. An initial conclusion which can be drawn is that of all of the comments received on both articles, less than 20% of comments indicated neutral sentiment. This shows that only a small number of respondents were unsure of their opinion in relation to the article. With such a small neutral sentiment displayed, the remaining opinions voiced can be determined to be widely polarised with the majority of respondents either advocating or dismissing the information provided. This speaks to the controversial nature of the material, even prior to a 'failure event' (Smith & Woodcraft, 2020).

Following Grenfell Tower, 6 news articles were analysed to determine perception and sentiment. These articles span 5 years running up the present and are from a multitude of news sources. Similar to the 2 articles prior to Grenfell tower, the initial 2 articles directly on the tail of Grenfell Tower similarly to previous articles exhibit headlines which are positive in nature, however these articles show the highest percentage negative sentiments of the investigation at 61% and 71% respectively. Additionally, the percentage of positive natured comments on the articles has decreased to less than 20%, almost equivalent to the accompanying neutral sentiment. This indicates that an increase in general hesitance towards the sustainable construction methods in question in the articles. This remains the trend seen in the data collected for the following 3 years of articles until the most recent article in 2022.

The final article examined shows a similar negative perception value, however the highest neutral percentage seen throughout the investigation. The reasons for this increase in neutrality are unknown however, it is also accompanied by the lowest positive value observed in the investigation. This indicates greater uncertainty than seen in previous years when discussing the emerging timber technology being discussed.

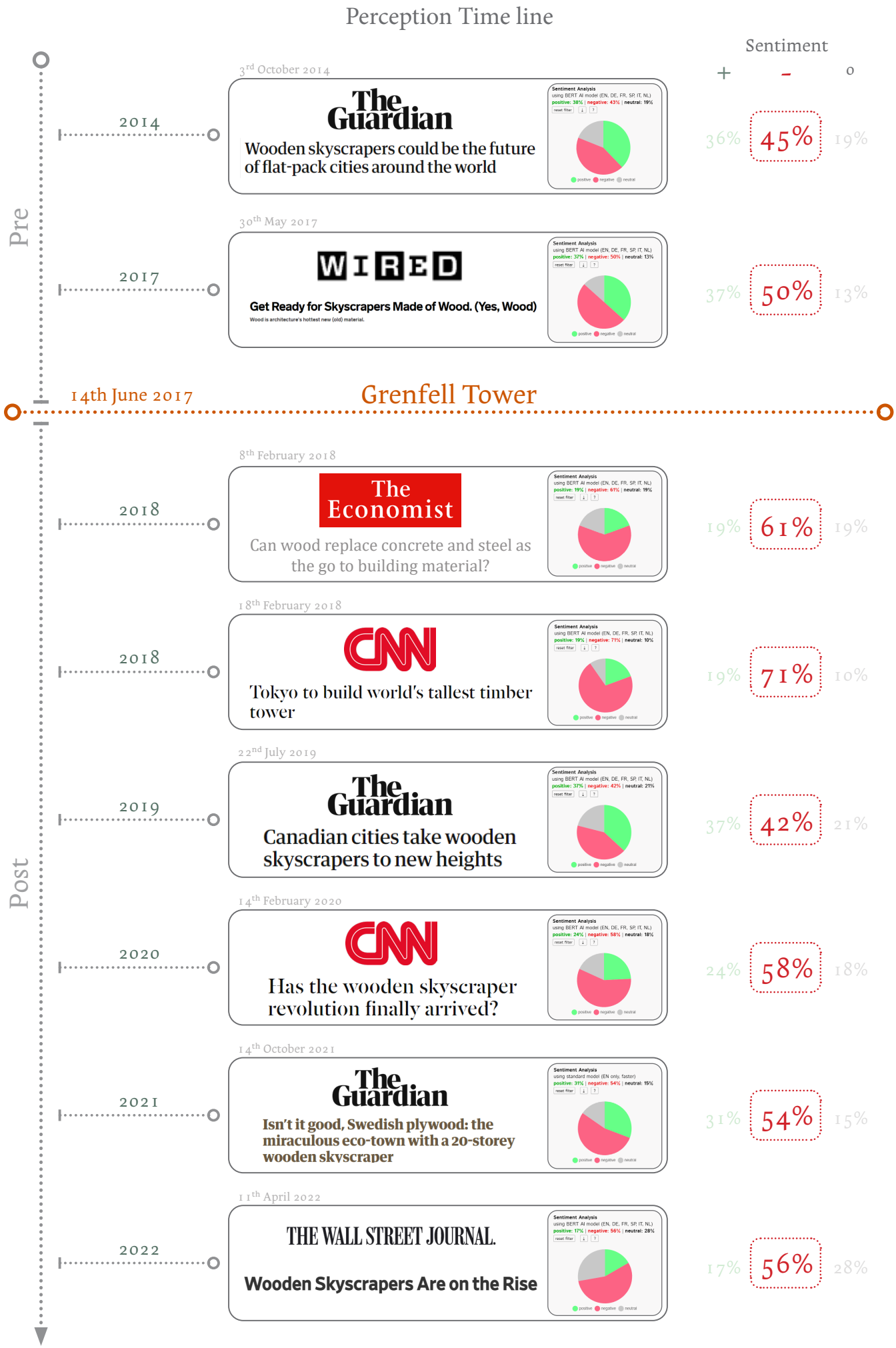


Figure 7. (Source: Author, created using Illustrator)

3.4 Conclusion

When examining the impact which Grenfell tower had on public perception, it becomes difficult to attribute Grenfell tower to the increased hesitancy directly as there are numerous variables which may have also affected the data collected. All of the articles statistically analysed produced a majority negative sentiment regardless of the original sentiment of the article title & content. The majority of fluctuation seen Pre/Post Grenfell was in the positive and neutral sentiment values. Both of the articles prior to Grenfell Tower had similar values for positive and neutral sentiment, whereas the articles in the years following Grenfell Tower saw larger fluctuation in these values. If the negative sentiment values for each article are averaged, it reveals a larger average negative sentiment following Grenfell.

Pre-Grenfell (Ave. %)

Positive – 36.5%	Negative – 47.5%	Neutral - 16%	No. Sources - 2

Post-Grenfell (Ave. %)

Positive – 24.5%	Negative – 57%	Neutral – 18.5%	No. Sources – 6

While differences are evident in these values, their statistical significance is questionable due to the number of data points available prior to Grenfell Tower. Fewer articles were found pre-dating Grenfell Tower, which may have been due to the recent increase in development & subsequent prevalence of timber construction technologies in the media. To more accurately determine the extent to which these results are valid, further investigation and data points would be required to confidently assert these conclusions.

Chapter 4 – Influences Upon Professional Building Practices

Introduction

Grenfell tower was an event which triggered a large number of changes and reforms in conventional building practices across multiple sectors of construction. The primary change in regulations were amendments made to the Approved Document B (Fire safety) however due to the extent of public enquiry associated with the amendment of such sensitive regulation, the document was not published until November 2018 (MHCLG, 2018). This left the construction industry uncertain of the measures which should be taken in the interim to address concern within ongoing projects, and subsequently what impact the eventual legislation would have on design practices. To gain an understanding as to how Grenfell Tower and the resulting regulation changes impacted practices, an architect and HSE Officer were consulted to gain valuable insight on how Grenfell as a landmark event impacted their profession.

4.1 Immediate Impacts

When speaking with the architect about the initial affects seen within their practice following Grenfell, they said that the initial impacts they observed were "*very reactionary*", and visible immediately and overnight. Their initial response focused on "*strategically reviewed all of our projects internally, forefront of our minds was in part to satisfy ourselves that we hadn't exposed ourselves, our clients, or our projects to any risk that was associated with the developing events and potential changes to legislation or legal action in the future*" (Architect, 2022). This highlights a key concern which will have been ubiquitous throughout the construction industries, safety of projects, people, and the uncertainty in upcoming changes. The initial uncertainty in regulations, fire safety, and exposure are all factors which somewhat evidently introduced hesitance into firm design practices. Following Grenfell, there was a period of time in which the construction industry remained in suspense awaiting the official changes to the regulations.

According to the architect during this period, "*Our duty in a lot of ways was to inform our clients that some of the schemes that we've been working on, the strategies that we had may not be appropriate in the fullness of time. We had to have frank conversations with a lot of clients to say we're doing this, and we are compliant with Part B as it is, but the fact that the regulations are due to change and will probably continually change meant we had to determine what their degree of acceptable risk in terms of the future compliance of their assets would be*" (Architect, 2022).

A consideration therefore of how practices continued to safely move forward anticipating the coming amendments became 'determining acceptable risk', and consequently "*transparency was key for architects trying to stay in control of what the moral obligations might be, which is never really something that architects directly address*".

Due to the varying stages of completion of projects, pending announcement of the amendments introduced following Grenfell Tower, a judgement of morality introduced into professional practice. This moral judgement had to be used to develop transitory mechanisms of how projects in different stages of progress could have regulations applied in the future, as otherwise "*if applied in full force, every job that was in stage 5 or 6 would have to remove or de-construct and rebuild a vast majority of the scheme, which is just not practicable*" (Architect, 2022).

Furthermore, to fulfil any internal concerns that may have arisen when proceeding with a project prior to formal guidance being released, the architects practice introduced an IMS system for fire reviews. This system required reviews at stage 2,3, and 4 of the design process, allowing all elements of the design process to be signed off as a method of internal compliance and safety checking. This was stated to be a "*good and positive change*" by the architect until ADB 2018 was formalised. Measures such as these were all pre-emptive as the eventual amendments to Part B would not be released until November 2018 (HM Government, 2018).

Architecture bodies such as the RIBA and ARB also regularly produced regulatory and advice documentation and press releases as a method of easing the transition between legislation releases, offering information to practices about how to proceed ethically and safely following the events, further reassuring the profession of appropriate continuation. (ARB, 2017.; RIBA, 2017).

While the methods of practice shifted following Grenfell, in the immediacy of the incident, the profession was left with a large amount of uncertainty with how to proceed safely and ethically while awaiting the formal guidance to be published, however obduracy was not observed in the most basic of definitions. Practices implemented changes independently of pending legislation due to perceived necessity. This ultimately represented a positive move in building practices to more morally and ethically sustainable practice.

4.2 Eventual Influence

Following the initial release of the initial Part B amendments in 2018, significant changes were made to building regulations. These included changes to external fire spread [a ban placed on combustible materials within the external walls of buildings exceeding 18m], materials [materials within the external wall of buildings exceeding 18m must achieve a European Class A2-s1, dO or Class A1 rating], and workmanship [building work shall be carried out with adequate and proper materials which satisfy the specified requirements] (HM Government, 2018).

Continuing from the previous conversation with the architect, they explained the changes observed within practice following the publishing of the 2018 amendments, stating that initially internal communication was circulated on company Intranet to ensure employees were aware of the new guidance, also highlighting employees that had been identified as CDM & Fire safety qualified personnel within the practice. CPD sessions were provided throughout the practice to better inform employees of ADB & BS9999 contents and requirements.

This is an apt method of ensuring architects and personnel involved in construction are aware of the most current regulations, something that becomes pivotal with the ever-evolving nature of building regulations, a topic expanded on further in conversation. "*Building regulations are a funny amalgamation of best guess assumptions based on lived experience and iterative amendments. I once spoke to a technologist about how the building regs had changed in his 40-year career and he said, 'when I started off an external wall U value could be met with a single brick'. The regulations evolve with the times as a series of reappraisals and additional sections.*" (Architect, 2022).

While the benefits of regularly amending regulations are clear, the question is raised as to what is the procedure through which regulation is amended, and what extent is public perception is able to influence this process. To provide information on this process, below is an extract from the conversation with the HSE Officer explaining the process through which legislation is amended and published.

> "*Regulation is subject to periodic reviews, performed by CONIAC (Construction Industry Advisory Committee), an organisation consisting of 20 industry bodies assembled to ensure adequate coverage of regulations is achieved throughout multiple sectors. The documentation produced or amended by this organisation is examined by regulatory law specialists before a consultation document with guidance and explanation is put out into the public domain, and then taken to public consultation. Following this any amendments are made and then signed off by secretary of state*" (HSE Officer, 2022).

Through the public consultation, the community is able to voice any concerns they have, with any concerns deemed to be relevant by the industry bodies then actioned before the document is signed off. This process removes the influence of preconception as the knowledge used to decide legislation is informed by extensive testing overseen by the industry bodies which make up CONIAC. This oversight provides the most current knowledge at that time, and therefore is able to dispel any outdated notions voiced by the public or indeed construction professionals. As a result, the aforementioned would all indicate that resistance to change is circumvented by the process of extensive testing and cross examination.

4.3 Professional Perception

Finally, to determine the opinion of the practitioners, during their respective interviews they were asked about their perception of timber construction methods, to determine if any significant hesitance was present.
Initially, the architect stated that they have not previously had extensive experience within their practice using engineered timber products due to the type of project they're predominantly approached to work on by clients, however additionally stated that "*I would have loved to experiment with novel materials [CLT], gone outside what we usually use and have the agency to specify something sustainable*" (Architect, 2022). This statement indicates that the architect personally was not averse to using CLT or similar products, providing their performance was compliant.

This was a similar view to the HSE Officer. They stated "*providing people have still got confidence that the up-to-date safety tests are as good as they can be, and it [Timber construction products] has all the right tickets [safety performance certifications], then yes, i'd have no problem using it. In some cases, I might even prefer it, if it were exposed internally as something with a nice aesthetic value and warmth*" (HSE Officer, 2022). Both of the consulted professionals appeared to have vastly positive opinions of the material, with no objections to its use providing it was able to meet all of the required standards.

The HSE Officer within their statement advocating for the material, may have however inadvertently raised a point which could warrant further investigation in a separate study, the question as to if the public still have confidence in the current safety standards following Grenfell. While legislation bodies possess oversight capabilities are able to remove the influence of obduracy, public perception is still able to influence construction when members of the public are the defined end user. If general public perception held no confidence in the safety standards which engineered timber projects were required to adhere to, it would be conceivable that developments employing this emerging timber technology would see lower uptake in ownership in these developments as a result of public hesitance. This would as Waugh Thistleton states potentially extend to securing a mortgage against a unit in a timber development (Waugh Thistleton, 2018, p92). Ultimately this could reintroduce a financial barrier to adoption, as if a developer is not able to sell properties in their development, they may refrain from using the material again, and therefore re-introduce obduracy.

4.4 Conclusion

While in the public domain, obduracy remains a prevalent concern when proposing new construction technologies, professional practice possesses methods of dispelling any obduracy which may currently be present. This is made evident in the opinions of the interview practitioners who appear not to be dissuaded from use of engineered timber products, providing they meet required standards. The current implementation of legislation oversight is evidently an adequate measure to remove the influence of public hesitance. However, public perception still plays a part in the implementation, since the end user is still able to influence the choice of materials. This shows that resistance to change (in the form of public perception) can infiltrate into building practices, despite existing legislation procedures and the willingness of practitioners to innovate. In lieu of amendments to building regulations, practitioners were introduced to exercising a more transparent, morally and ethically driven methods of practice, and while the now published amendments have added clarity to assumptions made prior, it would be hopeful that this transparency and ethical practice above what is mandated remains. Additionally, the amended regulations which resulted from Grenfell Tower have provided a more comprehensive and safer standard for construction from which to proceed with future projects, ensuring events of this catastrophic nature do not occur again. Furthermore this would begin to suggest positive and decisive moves towards more sustainable construction and general practices. As a result, the viability of sustainable engineered timber construction remains positive and will be discussed further in the following chapter.

Chapter 5 – Future Trajectory

Introduction

The discussion of engineered timber products among other sustainable alternatives as a credible replacement for currently commonplace materials in recent years has become an encouraging prospect, and been advocated for by multiple authors from differing backgrounds, however their large sale viability is an aspect which is rarely investigated in detail. This chapter will pragmatically present the driving forces behind progress, while examining the viability of future reform as a result. As part of this area of discourse, the previously discussed comments provided by an architect and a HSE Officer will be used to provide deeper insight to the influencing factors of such a complex socio-technical field.

5.1 Social Responsibility and Financial Sensibility

When discussing the theoretical viability of sustainable materials such as engineered timber products, the architect consulted provided insight into an area of concern which was not previously realised. "*The fact that CLT has a proven track record is irrelevant in an assembly where other parts of a build-up are weak. In today's practice, we're not predominantly interested in product testing, we're interested in systems testing. Until you've stuck all those products together and set them on fire, you don't really know how they're going to react*." (Architect, 2022)

Although statements made by previously examined authors have spoken admirably about the performance of CLT and engineered timber, the comment above introduces a previously unmentioned barrier and relevant consideration to wider adoption of the emerging technology. Systems testing is a much more extensive process than individual product testing, as it requires many common and conceivable construction types to be assembled at large scale for combustion testing to be performed on each system. In the interest of discussing projected future of timber products in construction, soon after in the conversation with the architect, an opinion was given regarding the initiative and investment they believed to be required to enact substantial change in this area.

> "*Well perhaps think about what is happening in petrochemical industry, where the emergent big players in investment in renewables are the oil giants, which is an oxymoronic reality. Really, they should be preservationists about their resources, but they know this change is coming and they know they're the ones with the agency to be able to enact it. They are the only people with enough capital to do it and be able to make mistakes. We have to trial things and to be able to engage in programs that look good from a corporate social responsibility perspective. Anyone else entering that sphere would have to have an equal amount of money, capital & liquid and would have to have as much political and social influence as those big players do, and it would be somebody as big as Kingspan in my view, that would be able to get wood fibre insulation off the ground.*" – (Architect, 2022)

Trials of the scale discussed are large financial expenditures, consuming extensive amounts of time to achieve the required regulatory approval necessary for the desired widespread roll-out being debated. Elements from the architect's statement provide provocative points which begin to indicate obduracy, but not driven through hesitance deriving primarily from concerns relating to fire safety performance, but from the financial expenditure required. While not absolute, within architectural circles the knowledge surrounding fire safety performance may currently be prevalent enough that it does not produce a significant concern. Whereas the number of programmatic considerations, additional large-scale testing, and time required to implement any significant change in prevalence may exceed the materials perceived benefits.

Later in conversation, the architect also raised an additional point which impacts the financials involved further. "*Business as usual is positive, productive, efficient and cost effective, which is partially why we weren't, or we aren't still more forthright in our promotion of timber as an available primary construction means I believe*"(Architect, 2022). This comment during the interview was in relation to the business side of an architecture practice, and how clients influence the design and construction. The architect explained that returning clients choose practices which they know they are in a safe pair of hands with, that what they got last time was delivered well, and wish to repeat this result. It would be seen as bad business for an architecture firm to fundamentally change their standard practice. Adopting timber as a main construction material may cause the returning client to question this conviction, which in turn would have financial implications to the firm. It provides further evidence that the hesitance towards adoption of more sustainable engineered timber products is primarily a problem of financial sensibility within professional practice.

5.2 Sustainability as a Regulatory Necessity

To speculate further on the interview comments provided, questions are raised in relation to emerging technologies and how legislation can dictate their deployment. With the 2018 Part B amendments banning combustible materials in the external walls of buildings over 18m, the scope of materials available for insulation, cladding, external attachments and more, became vastly limited. This reduction in scope however may trigger positive steps in development of sustainable, and non-combustible alternatives. The architect consulted mentioned wood fibre insulation as a potentially feasible, sustainable product. It would not currently meet the required regulations as it would be classed as combustible, and therefore prohibited. While regulation could conceivably be seen as impeding sustainable design through removing any non-conforming sustainable material from circulation and reducing range available, more optimistically, legislation can be viewed as provoking innovation. Grenfell tower serves as an example of how rapidly legislation can respond and reform building practices in the interest of safety, and as a result a case can be made for legislation to be used to increase the speed of deployment of sustainable materials. In this context, legislation facilitates the creation of a new market for material development.

While the large amount of development, systems testing and publicity which would be required to satisfy public, professional, and governing bodies in the short term, serving as a limitation, it would provide a financial incentive to product manufacturers to provide products which are both non-combustible and sustainable in the long term. If sustainability was outlined as a regulatory necessity, it would override the mentality that "*business as usual is often not questioned until it is an absolute necessary to do so*" (Architect, 2022). It shouldn't be a case of waiting until something catastrophic happens before we change our mentality and our focus. This change would aim to tackle obduracy through associating financially motivated construction with sustainable design, more explicitly it would make sustainable and environmentally conscious design the most financially and legally viable choice, and therefore become industry standard practice.

To follow upon the previously debated possibilities, sustainability as a legislation requirement was discussed with the HSE officer. They raised the point that sustainability as a necessity in legislation in their view already exists through BEEAM ratings and specification of minimum U/R/G values for building components and build-ups. They further elaborated stating that "*It's [sustainability requirements] already been there for decades now, but I also think that, we are absolutely going to have to get to sustainably sourced and constructed buildings, we can't not* "(HSE Officer, 2022). As a result, sentiment within the regulation industry would indicate optimism. Sustainability in legislation does presently exist, and while it could be more explicit and prescriptive, it can only progress at a commensurate rate to the technology which it regulates. It will move towards the requirement of sustainable methods in construction, but this will take time.

5.3 Social Value

The previously mentioned indicators demonstrate that the shift to more sustainable practices is already beginning to gain significant traction. However, the HSE Officer provided an additional indicator of the speed of progression of the process. They stated that a mechanism through which sustainability in the construction industry is beginning to be driven is through social value. "*We've now got at least 15 to 20% of every one of our tenders usually being assessed on social value*" (HSE Officer, 2022). Social value as a concept has rapidly emerged in the past 5 years and become popular as a method for businesses to appear outwardly socially conscious. TOMS frameworks (Themes outcomes and measures) are one of many implementations of this. The framework allows for the production of data metrics which measure social value, and allows businesses to win more contracts through active contribution to social value. (HSE Officer, 2022). The emergence of this framework indicates a relationship between sustainability and business-as-usual, and that progress is being made in addressing obduracy within construction. To highlight the importance and prevalence of social value, in 2015 with the release of the UN sustainable development goals, social value as a concept was influential in multiple goals in the pursuit of sustainable progress. (The United Nations, 2015)

United Nations Sustainable Development Goals

Goal 11 - Make cities and human settlements inclusive, safe, resilient and sustainable

Figure 8. (Source: The United Nations, 2015)

Social value can also serve as a method of addressing the increased costs currently associated with using more sustainable materials. The HSE Officer presented the example of Ultralite concrete blocks, and the influence social value has had on reducing the price of this product. Previously using concrete blocks on construction sites introduced health and safety risk of handling and RSI due to its weight. Ultralite blocks were introduced as a lightweight alternative to traditional concrete blocks, weighing 1/5th of that of a traditional concrete block, but initially were 5 times the price. HSE however adopted the Ultralite blocks citing social value as their justification. The HSE officer stated that;

> "*they started marketing their wares, saying were an empathic employer as we advocate the use of this product which won't produce workplace injuries and RSIs associated, and therefore lead more productive lives. It's got to the point where the lightweight ones are cheaper than the heavyweight ones and there's no longer that dichotomy in price*" (HSE Officer, 2022).

While concrete blocks are not inherently an example of a sustainable product, through social value a more virtuous product became more accessible and as a result has been adopted in business-as-usual practice. This same mechanism which social value makes possible could be easily applicable to sustainable construction products, contributing to sustainable progress.

Chapter 6 – Case Study

Dalston Works - London, UK - Waugh Thistleton Architects

Dalston Works - Waugh Thistleton Architects

Figure 9. (Source: Waugh Thistleton, 2018)

Introduction

To demonstrate the real-world potential for the technology previously discussed, a landmark and exemplar CLT building will be presented to situate conclusions made throughout this investigation. The project which will be presented is Dalston Works in the London Borough of Hackney, the 'world's largest CLT building'. Delivered by Waugh Thistleton Architect in 2017, the 10-story mixed use scheme is constructed entirely from CLT, providing 121 residential units and 38,000m^2 commercial area. As stated by Waugh Thistleton, "*Dalston Works showcases how CLT can help deliver high-quality, high-density housing without compromising the environment*" (Waugh Thistleton, 2018, p229) and has been widely praised by multiple originations and architectural press as "*innovative*" and "*pioneering*" (Architects Journal, 2017; Dezeen.com, 2017).

6.1 Sustainability

The project completed in June 2017, initially heavily publicised the benefits of its construction and sustainability. This was achieved through using sustainably sourced CLT to construct over 90% of the building, and as a result the 4500m^3 of timber used stores 3750 Tonnes of CO_2 within the building structure. This contributes to offsetting the CO_2 produced by transport of materials, the manufacture of bricks and the energy consumption of the building for multiple years to come. The affect is a net embodied carbon of -2878 tonnes CO_2e, a rarity in construction as currently the building and construction sector accounts for 39% of annual CO_2 emissions globally (IEA, 2019, p9).

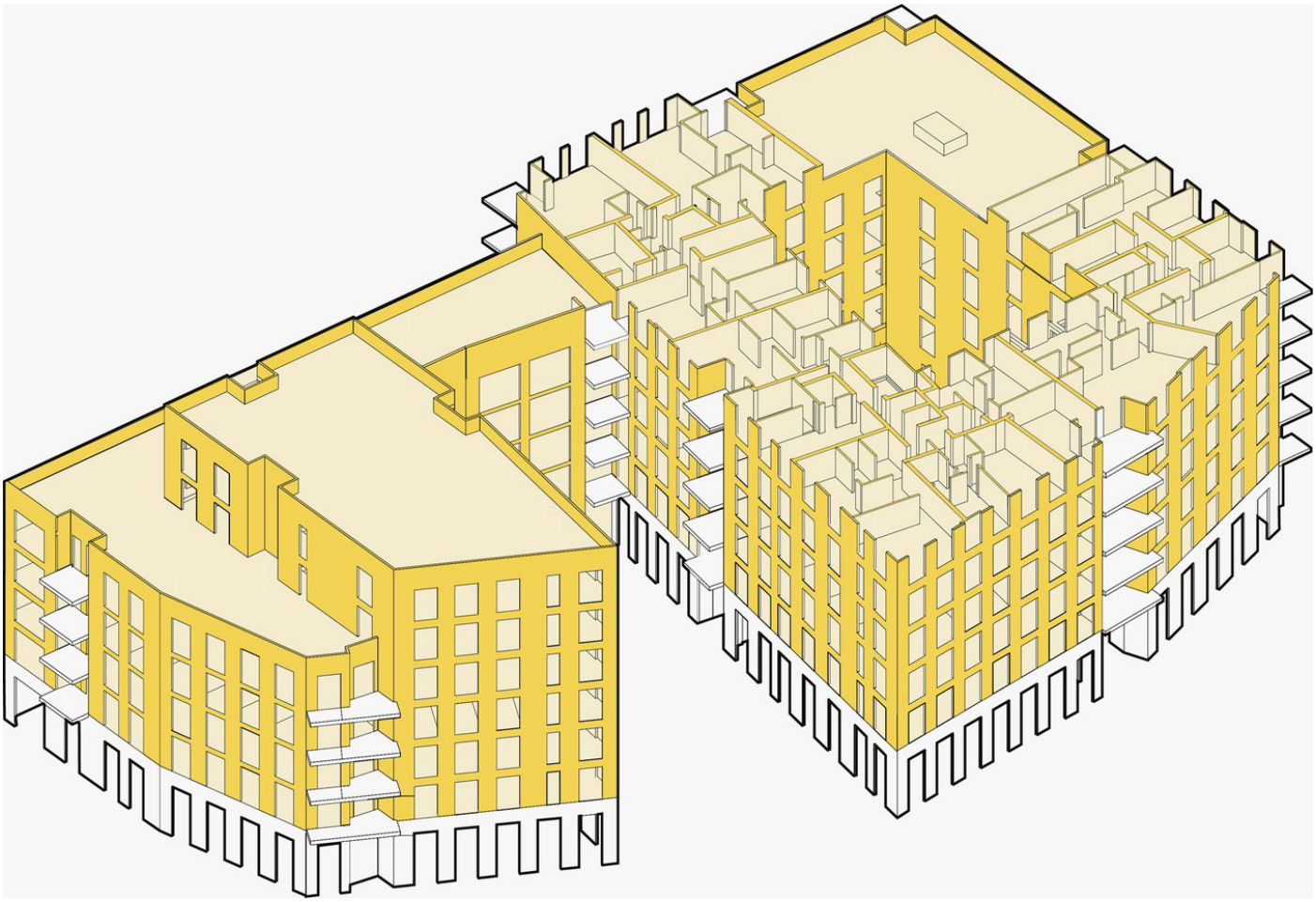
Dalston Works - Waugh Thistleton Architects

Figure 10. (Source: AJ Building Library, 2017)

6.2 Social Value & Financial Sensibility

This represents a large achievement for the project, and subsequently the wider construction industry regarding social value. As established in prior scholars' studies, the public view sustainability as an admirable 'soft' criterion for a building, also appreciating its warm aesthetic quality. Within the project, large amounts of the CLT construction have been left exposed internally for both aesthetic quality and well-being, however, this also serves as a subtle reminder of the inherent sustainability of the building. Dalston Works would therefore be looked upon admirably by the public as a result of its embodied social value, and potentially justify the financial sensibility of CLT construction to the developer. As an additional consideration in terms of financial sensibility of the material, Dalston Works serves as an apt example of an emerging construction technology being used to increase the residential density. The site the building is constructed on was previously classed

as undesirable brownfield land. Waugh Thistleton states "*constrained by the future Crossrail 2 train line that runs under the site, the CLT weighs a fifth of a comparable concrete structure. This reduced weight combined with the minimal raft foundation enabled the creation of 35 additional homes than would have been otherwise possible in concrete frame*" (Waugh Thistleton, 2018, p229). The significant reduction in weight achieved with CLT affords a developer a large financial incentive in certain cases as they are able to increase the number of residential units possible and therefore produces a strong point advocating for engineered timber construction.



Dalston Works - Waugh Thistleton Architects

Figure 11. (Source: AJ Building Library, 2022)

6.3 Future Prospects

With Dalston Works located in the UK, it is subject to stringent building regulations, which as previously stated are frequently amended following appraisal and significant events. The completion date for the project was June 2017, the same month of the Grenfell tower incident. As a result, Dalston Works, like many other projects around the UK was interrogated to determine its safety pending the Part B amendments. Upon their release Waugh Thistleton released a news statement in response which indicated they remain absolute in their advocation. "*The new legislation does not propose a ban on engineered timber or CLT structures, it will simply change the way we build tall timber residential buildings*" (Waugh Thistleton, 2018b). This is a positive statement which indicates that they do not feel that the 2018 Part B amendments will inhibit progress towards sustainable construction methods, or significantly impede development of CLT building technology.

Chapter 7 – Conclusion

Firstly, this investigation shows the complexity of resistance to change. It is not only found in public perceptions, as influenced by major events or 'the familiar' but a complex amalgamation of socio-technical financial and legislative aspects. It has been presented that obduracy or resistance to change remains present within the public and professional consciousness. When comparing to the obduracy presented by previously examined literature however, the method in which this manifests is somewhat different. Public concern remains focused around fire safety performance and durability, something which has only been intensified by Grenfell Tower, however the importance which the public now place on sustainability in construction has transitioned from being considered a 'soft factor' to something of higher importance. This shift has been somewhat driven by the recent increase in prevalence of social value in both the public eye, and professional practice. It has been revealed to be a powerful mechanism which businesses are able to utilise to make construction simultaneously more sustainable and financial beneficial. The increasing prevalence of sustainability and social value within the public domain could prove to be effective at addressing hesitance within the general populous, and therefore increase the rate of evolution of public perception. Additionally, the obduracy observed within professional practice, rather than being driven by safety and durability concerns resulting from unfamiliarity as shown in prior empirical studies, has become driven primarily by programmatic concerns such as project time lines, labour force familiarity and lack of costing experience. Legislation has begun to address how sustainable construction methods can become financially viable for businesses. Recent introductions of social value requirements when procuring and bidding for projects have begun to gradually introduce sustainable necessity at a rate at which provides little disruption, while improving perception in public domain.

While some of the methods used to perform this investigation introduce some inconsistency, and significantly more data would need to be mapped to form statistically significant conclusions, using social media to build an understanding of public perception has been a useful technique to allow information to be easily gathered. Providing that an understanding that the comments voiced will be polarising due to the nature of the platform is reached prior to conclusions being drawn, some inconsistency can be removed from the investigation. This method of analysis however potentially affords the "worst case scenario" of perception to be examined, a useful insight when determining how to tackle critical public perception.

While a case for the implementation of timber products in bespoke and specific projects remains a promising prospect, social responsibility and the financial sensibility are still in the progress of beginning to compliment and align with one another. The advocation for widespread adoption of engineered timber products in mainstream residential high-rise construction will remain a controversial region of architectural discourse, however ongoing gradual shift in legislation, public opinion, and business ideals makes this an ever more possible eventuality.

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