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ABSTRACT

Purpose: This research explores contemporary attitudes amongst UK construction professionals regards fire safety post the Grenfell Tower disaster. Specifically, the research examines practitioner's perceptions of fire safety design, material specification, construction and maintenance of high-rise blocks throughout a building's whole life cycle.

Methodological Approach: A multi-methodology approach was adopted that utilises a mix of research methods. Extant literature and media content is used as a secondary data source, providing a more insightful interpretivist analysis – the results of which guided the development of the survey's main question set. Primary survey data is sourced from structured interviews and questionnaires completed by participating industry professionals and built environment undergraduate students using non-representative sampling methods. In addition, a Grenfell Tower special advisory panel member was interviewed to add further validity to the overall findings.

Findings: The quantitative findings present evidence to suggest that~~illustrate that~~ the Grenfell disaster (and media storm that has surrounded this event) has raised the general level of fire safety knowledge and competency amongst construction professionals. However, qualitative feedback from the special advisory panel member suggests specific fire prevention knowledge remains elusive within both industry and taught programmes at Higher Education Institutes (HEI's). As a consequence, changes in the taught curriculum are proposed together with an extension of the role of facilities managers in practice to cover fire safety in greater depth.

Novelty of research/originality: This paper provides thoughtful insights into the contemporary discourse on fire-safety within the UK construction industry. The research also provides critical suggestions to both industry and policy makers which seek to prevent a repeat tragedy occurring again.

KEYWORDS

Grenfell Fire, Cladding, Legislation, High rise, Regulations

INTRODUCTION

Fires in high rise buildings are challenging in terms of logistics, fire suppression and the building's physical structure (Hassanain, 2009). For example, the prominent World Trade Centre (1 and 2) incident which gained significant international attention, claimed almost 3,000 lives and the towers collapse *"due to the temperature of the fire and loss of the structural integrity"* (Eagar and Musso, 2001). More recently the Grenfell Tower, a 24-storey residential building in North Kensington, London, caught fire causing 72 fatalities (Potton, 2018). The fire began on the 14th June 2017 when a faulty refrigerator ignited on the fourth floor (*ibid*). The fire passed through open windows to the building's external skin, leading to an unprecedented speed of spread. Within two hours the tower was engulfed in flames, trapping the remaining residents (BBC News, 2018). Following the disaster, the construction industry has faced numerous challenges and questions regarding how the event occurred and what could be done to prevent similar disasters on that scale from occurring again. While adopting a preventative strategy

towards the design and construction of a building should be encouraged, it must be noted that such an approach only provides a partial solution because the building's whole life cycle (including maintenance works undertaken post occupancy) must be considered. Therefore, in addition to architects and contractors, other stakeholders such as facilities management teams and the occupants themselves must be consulted with.

In 2018, the Fire and Rescue Services (FRS) attended *"805 fires in purpose-built high-rise flats in England, an 11 per cent increase compared with the previous year 727"* (Home Office, 2018). According to the UK's Home Office, 72 out of the 247 fire-related fatalities in 2018 (or 28.75%) were Grenfell fire victims (Home Office, 2018). The Royal Institute of Chartered Surveyors (RICS) have since released various documents and articles relating to post-Grenfell fire safety and evacuation plans. Yet curiously, the same level of fire safety rigour has not transcended professional body accredited taught undergraduate programmes – hence, future generations of construction professionals still remain largely ignorant of the risks posed. Consequently, it has become increasingly apparent that the industry has not consistently applied these reforms: Strong (2018) suggesting that despite globalisation and an increase in financial investment going into built assets, the construction industry has shown very little interest regards maintaining a high standard of design, construction and management/maintenance of buildings in terms of fire safety. Similarly, the Polyisocyanurate (PIR) industry (a major materials supplier to the construction sector) has faced dramatic scrutiny post-Grenfell as the cladding was a major factor contributing to the rapid spread and flashover stage of the fire (Mitchener, 2018). The manufacturer 'Celotex' confirmed they supplied the rainscreen cladding system made of thick PIR and aluminium composite panels with a 50mm air gap was fitted onto the façade of the tower (*ibid*). This was done for both aesthetic and thermal insulation purposes (Knapton, 2018). Following public outrage and media scrutiny, Celotex has since discontinued the product (Grenfell Tower: Celotex updates and information, 2018). The government has subsequently opened a public inquiry and arranged for an 'independent expert advisory panel' to shed light on the matter and decide how to move forward. Indeed, local government have identified that 299 other tower blocks in London have a similarly flammable cladding system (Local.gov.uk, 2018). The threat of a such incidences consequently remains imminent (*ibid*).

Against this contextual backdrop, this research seeks to review extant literature and garner professional practitioner opinion on the relationship between high-rise towers and fire safety – and ultimately answer the research question: *"can similar catastrophic events be avoided."* In particular, the research will focus upon the aspects of building design, means of escape and an analysis of the cladding skins relationship to fire spread. Cumulatively, the work provides invaluable insight into how the construction industry aims to prevent disasters such as Grenfell occurring again and highlights contemporary attitudes of professionals within industry and wider society about occupant safety. The primary objective is to ensure that current and future generations of construction professionals are educated at Higher Education Institutes (HEIs) with core 'fire safety knowledge' inbuilt into the curricular. Furthermore, practical recommendations will be made to transform political policies to focus more upon a grassroots approach to education and skills enhancement.

DESIGN AND FIRE RELATIONSHIP

Post world war two (WW2), the insatiable demand for housing became apparent and it was estimated that approximately 750,000 new homes were required in both England and Wales (Fet.uwe.ac.uk, 2018). This led to the 'Tower Block Boom' which sought to provide the public with affordable housing (Child, 2018). During this time, a brick shortage combined with a discernible lack of brick manufacturers encouraged the government to create a viable solution that could provide fast construction, require little space and alleviate homelessness - especially during the baby boom period (Kuchler, 2018). Inspired by brutalist architecture, the then impressive 24 storey Grenfell tower was constructed using concrete panels to dominate the adjacent skyline and meet the insatiable public demand for affordable housing (Fet.uwe.ac.uk, 2018; Kuchler, 2018).

However, post the disaster, academics and practitioners alike argued that the upward design of a tower block could contribute to fire spread (Cowlard *et al.,* 2013). In Grenfell, the upward flames moved in the same direction as air flow and buoyancy, taking many lives in the process (Jiang *et al.,* 2018). In residential fires, fatalities are often due to the smoke inhaled and this smoke can travel rapidly dependant on material interaction particularly in an upward fashion. Fires spread through windows to the outside, whilst lift shafts and other opening hasten the spread through vertical movement (Black, 2009). Architects and post disaster investigations highlighted that the Grenfell tower design failed in several ways as a result of maintenance and renovations undertaken during the occupancy phase of the building's whole life cycle, namely: cladding, windows, doors and the stairway (Jessel, 2019).

Cladding

Rainscreen cladding supplied by Celotex failed several fire tests proving it to be inadequate for residential spaces yet this was specified by construction professionals. This suggests an issue in the logistics of specifying and supplying appropriate materials within the industry (Rogers and Gardiner, 2018). Before the tower renovation, the cladding of Grenfell was *"precast ceramic panels"* which is widely known to have great fire resistance (Woodcock and Macguire, 2018). Reasons for re-clad were myriad and include meeting stringent energy saving targets. Specifically, the new cladding material was considered to be highly combustible and poorly installed, suggesting a quality issue as well as possible neglect (Jessel, 2018). Dr Lane, Arup's Fire Engineer stated that the defective cladding contributed greatly to a *"successful combustion process"* (Price, 2018).

Windows

Newer windows installed during renovations were smaller, and this created a gap around the original frame which was then filled with a weatherproof seal called 'Ethylene Propylene Diene Monomer (EPDM)' (Grenfell Tower Inquiry, 2018). These windows were made of highly flammable 'PMMA-polymethyl methacrylate' powder coated aluminium (Woodcock and Macguire, 2018). This lethal combination of flammable material and air gap between the window and the concrete frame allowed fire to spread through easily (Mairs, 2018).

Doors

Replacement of doors was a part of the renovations and Dr Lane found *"serious discrepancies"* between how the doors were designed and installed (Price, 2018). The doors were different in terms of locks and hinges and furthermore, the intumescent seal used was also different which

also contributed to fire and smoke spread (Oldfield, 2018). The metal fittings and door seals embedded into the doors were inconsistent in terms of melting point specifications. This minimised fire (and hence smoke) resistance performance (Grenfell Tower Inquiry, 2018), resulting in smoke entering various parts of the tower before the flashover stage.

Stairway

Reports also revealed that exposed gas pipes and duct services which ran alongside the staircase greatly diminish the fire rating of the stairways (Booth *et al.,* 2018). The fire doors to the staircase were FD30 (fire rated for 30 minutes) which meant that they were not compliant with current building regulations (FD60 – 60 minutes) as they had not been updated/replaced since 1972 (Grenfell Tower Inquiry, 2018). Importantly, following the fire, tests were conducted on doors from the same manufacturer and the results concluded that they failed the 30 minute mark (Pitcher, 2018). This deficiency resulted in jeopardising the only escape route available to residents.

REGULATIONS AND STANDARDS

Table 1 presents government documentation offering guidance regarding the fire safety of external cladding depending on location. England and Wales are subject to guidance stated in the 'Approved document B – which states that according to the 'Regulatory Reform Fire Order 2005' (RRFO), employers or any persons in control of the building must carry out a risk assessment to deem if the building is fit for purpose and safe for residents/occupiers. In terms of fire, this would be a fire risk assessment which will identify and evaluate risks posed in terms of recognising potential sources of ignition, combustible materials, efficiency of escape routes and preventing fires (A guide to fire safety and performance in fire, 2018).

<Insert Table 1 about here>

The RRFO states that *"emergency routes and exits must lead as directly as possible to a place of safety"*, in order to provide a basic means of escape. There is also guidance provided in terms of specific components such as door widths and the number of occupiers/residents (Firesafe.org.uk, 2018). In buildings, this would be fire escape doors, fire exit signs, emergency lighting etc. To provide fire safety and escape in buildings, passive and active measures could be installed (refer to Table 2).

<Insert Table 2 about here>

Passive methods are precautionary measures that passively inhibit the effect of fire and its spread (Buildings.com, 2018; Hse.gov.uk, 2018; Marsden-fire-safety.co.uk, 2018). These include: i) dampers to prevent the spread of fire/smoke throughout the building through its ductwork (Buildings.com, 2018); ii) photo luminescent egress to light up the path to safety when smoke obscures visibility (Marsden-fire-safety.co.uk, 2018); and iii) fire doors help to compartmentalize a building. The latter is necessary because compartmentalising your building into smaller sections will slow the spread of fire and this is important for escape (Buildings.com, 2018). Conversely, active methods are those that actively combat the spread of fire or act to alert occupants to the danger. These include: i) smoke alarm systems (Hse.gov.uk, 2018); ii) fire extinguishers and firefighters to help extinguish fire (Burton, 2018); and iii) sprinkler systems to help slow the growth of the fire (Hse.gov.uk, 2018).

INDUSTRY VIEW AND PRACTITIONERS' UNDERSTANDING OF FIRE SAFETY AND REGULATION

The construction industry has faced scrutiny after the Grenfell fire particularly with regards to competence and neglect (De Selincourt, 2018). The sector responded by having key figures issue statements regarding the tragedy and also by providing more conferences to kick start 'conversations' regarding how fire safety is viewed within the industry and what improvements could be implemented (*ibid*). The RICS and Chartered Institute of Buildings (CIOB) have issued statements of condolences and have attempted to engender a discourse regarding fire safety, but the industry still displays a *laissez-faire* attitude towards the matter. For example, Paul Nash Past President of CIOB stated that: *"recent tragic events at Grenfell Tower have further underlined the need for an urgent review of the way in which quality is managed in our industry"* (Atherton, 2018). This sentiment is shared by Fire Sector Federation Chairman who commented *"we are gravely concerned in particular about the whole design, specification, supply chain and construction process"* (*ibid*). Conferences and workshops regarding the specification of defective materials and best practice have taken place post-Grenfell yet, these events tend to involve senior members of the industry rather than reaching out to younger professionals within the industry or even HEIs who train and educate them (Architecture.com, 2018). Currently, Universities with Built Environment Faculties have yet to infuse fire-safety and material specification awareness into their curriculum thus illustrating that the political rhetoric from the construction sector has been grossly exaggerated.

The Mayor of London, Sadiq Khan, issued an open letter to the Prime Minister Theresa May urging her to issue a public inquiry to investigate the events (Khan, 2018). This sought to establish what could be done in the future to prevent similar disasters – for example, the Kings Cross Station fire which had a number of fatalities and followed a similar pattern in terms of having a public inquiry with a 'independent expert panel' to corroborate the facts and find a way forward (*ibid*). Dame Judith Hackitt, of the independent advisory expert panel expressed that just because a design passes building control does not necessarily mean it is safe. Hackitt (2018) argued that the current regulatory system is not serving its purpose and quality assurance in materials and peoples is *"lacking."* Figure 1 shows a timeline of recent legislations, regulations and action taken to implement better fire safety in UK housing (Rla.org.uk, 2018).

The Hackitt report highlights deep flaws within the prevailing system and found that a prominent reason for the building's failure was ignorance (Mairs, 2018). Ignorance was an issue because industry professionals were unaware of guidelines set for fire safety in dwellings or other buildings because they do not read the documents available to them (*ibid*). Lack of clarity in roles and responsibilities was another issue within the industry due uncertainty of responsibilities as a result of how fragmented the industry is (Simpson, 2018). In other words, decisions about *"design, products, competency and auditing"* are made in a dysfunctional manner and often do not consider fire safety implications (Read, 2018). This leads to a lack of accountability which then sets in motion a blame culture which detracts from the issue at hand, neglecting fire safety and how improvements can be made (Building Support: the review of the industry training boards, 2017). Another issue the report highlighted was indifference to quality with materials procurement decisions driven by 'quick and cheap' versus those materials that comply with pertinent regulations set out by the government (Corruption Report, 2013). Furthermore, pleas to

improve a buildings' quality, or correct an omission or error, are often ignored; something that ties into the lack of accountability displayed by professionals. In particular, complaints from residents being ignored is quite common but in Grenfell costed lives. This begs the question resonating through the media: *"have lessons been truly learned?"*

<Insert Figure 1 about here>

The independent fire advisory panel went on to suggest recommendations moving forward. The recommendations are set out in relation to

> *"parameters and principles of a new regulatory framework, design, construction and refurbishment, occupation and maintenance, residents' voice, competence, guidance and monitoring to support building safety, products, golden thread of building and procurement and supply"* (Hackitt, 2018).

The goal is to deliver the recommendations and develop a *"joined-up implementation"* to ensure they become a normality in the industry: ostensibly to encourage a cultural shift aimed at bringing about some legislatorial changes – refer to Table 3 (Hackitt, 2018). Following the report, the government mandated that a £400 million fund to be made available to councils and housing associations to remove and replace all unsafe claddings. To facilitate this, the UK government prepared a 'building safety programme' which outlines the materials banned from high-rise buildings including details of investigations on fire doors (Brokenshire and Hammond, 2018).

<Insert Table 3 about here>

MEDIAS INFLUENCE

Britain's inequality issues are heightened - especially at a time of austerity where daily protests regarding some form of inequality occur (Devey, 2017). The media played a tremendous role with publicising and influencing public opinion regarding the Grenfell disaster. Within the UK, tower blocks are often associated with poverty and described by Hanley (2018) as a 'high rise slum'. It is apparent that the demographic who resided in Grenfell Tower were from the low-income sector and many were on some form of income support (McKee, 2017). The media contributed to public outrage, particularly due to the fact that shoddy construction work and derelict material were used on a tower block in Kensington; one of the richest boroughs in the world. Yet survey reports in 2015, revealed that Grenfell and the area in the near vicinity were amongst the top 10% of the most deprived areas in England (Ahmed, 2018). Residents expressed how the Royal Borough of Chelsea and Kensington ignored complaints from Grenfell residents ranging from exposed gas pipes to concerns about evacuation routes and it was suggested that this is a bigger part of gentrification and social cleansing agenda in Britain (Booth *et al.,* 2018) (Elmer and Dening, 2016). Beinazir Lasharie, a Labour Councillor and a resident nearby who was evacuated at the time of the fire, provides a deeper perspective:

> *"We are a nuisance to the council. Their attitude is: how dare so many ethnic minority foreigners who are not well-off live in these ugly flats ... They don't care about us, they don't listen to us. It's as if they want us to move out* (MacLeod, 2018)."

The public response was a driving force to the open letter issued by the Lord Mayor of London to Prime Minister Theresa May, which then led to a public inquiry. However, the inquiry is predicted to stretch to beyond 2019 and, following the recommendations set by the independent expert advisory panel, legal changes have yet to be made, suggesting that improvements may take some time to be implemented.

RESEARCH METHODOLOGY

This paper adopts inductive reasoning to achieve a tentative hypothesis (Thomas, 2006) and triangulation (using both qualitative and quantitative data) will answer the research question posed (Bird and Barker, 1985). A multi-methodology approach was adopted because it incorporates methods from both the positivist and interpretivist paradigms (Johnson and Onwuegbuzie, 2004). Elimination of researcher bias is an advantage of mixing research methods, as well as challenging the weaknesses faced by both qualitative and quantitative approaches (Mahmood, n.d.). However, the interpretivist epistemological lens as part of an inductive research approach has several significant limitations such as a failure to generalise the findings (cf. Roberts *et al.,* 2019). These limitations apart, the interpretivist approach does generate new theories that guide future research investigations. From an operational perspective, the research consisted of a three stage process, namely: i) a pilot study of the data collection instrument; ii) the main survey study; and iii) expert interview. Given the purpose of the research, using a questionnaire was beneficial because it is a *"convenient way to compare data"* from the sample by collecting the views and perceptions of the participants (Mathers *et. al.,* 2007, p.20). Although questionnaires can manifest in different forms (Ponto *et al.,* 2010), this research adopted an internet based questionnaire because they are inexpensive and provide ease of delivery to participants.

Pilot study

A pilot study for an on-line structured questionnaire was used to trial and test the method and to determine whether it was appropriate for the investigation (Abu Hassan *et al.,* 2006). Participants from the pilot study were selected using opportunity sampling (Methods.sagepub.com, 2018) and included two final year quantity surveying students, a senior cost consultant and two fire engineers. These participants were selected because of their knowledge, years as a young graduate, or as an experienced industry practitioner. Each participant was requested to sign a consent form prior to completing the questionnaire and was assured of their confidentiality (Oliver, 2010). All participants were told that all data collected would be disposed of securely, and that all personal details would be kept strictly confidential. As a vehicle for questionnaire delivery, the on-line portal consisted of close ended questions to secure a high response rate (Luthy *et al.,* 2007). Structured questionnaires were used in industry and a HEI setting to assess whether participants kept abreast of contemporary fire safety issues. Likert items were used to measure the scale of agreeing/disagreeing to measure attitudes; where 1 = Strongly Agree; 2 = Agree; 3 = Neither agree or disagree; 4 = Disagree; and 5 = Strongly Disagree (Questionpro.com, 2018). The on-line questionnaire contained a total of 9 questions – two qualitative questions and 7 quantitative (refer to Appendix A).

Main survey sample design and selection

Snowball sampling is utilised for primary research to achieve a representative sample for the questionnaire (Martínez-Mesa *et al.,* 2016). Snowballing sampling is cost effective and easy to

prepare and hence, makes it possible for the study to be completed in a short amount of time (Faugier and Sargeant, 1997). For this research, the respondents vary from undergraduate students on the Bachelor of Science (BSc) Quantity Surveying or Construction Management course to professionals working in 2 different companies; one being a cost consultancy and the other a major engineering firm. The cost consultancy company was a large sized company, employing up to 5,000 people worldwide with an annual turnover approaching £50 million per annum – the company has extensive experience of working on high-rise developments, hence their inclusion in the study. The engineering firm is also a large sized business with over 10,000 employees worldwide and an average annual revenue of $20 billion (US dollars) - this company has worked on a variety of considerably high profile projects including high-rise developments, which means that their employees could provide valuable input into the questionnaire's development. With the use of snowball sampling, the sample of respondents network and provide other professional connections leading to a wider range of those willing to participate in the research. This created a bigger response pool from those with greater knowledge of the industry (Browne, 2005). A limitation of this design is that a larger random sample, geographically distributed throughout the UK may have generated different results hence, the findings are more indicative vis-à-vis definitive. Statistical analysis of the quantitative data collated is analysed using summary statistics in Microsoft Excel (Bhatia, 2018; Research-Methodology, 2018).

Expert interview

A semi-structured face-to-face interview was also undertaken with a Grenfell fire and construction expert. The interviewee was a senior member of the industry with decades of experience and 'current' knowledge of the Grenfell tower situation having been involved in governmental discussions about the incident. The interview sought to provide a primary insight into the industry's and government's view and perhaps draw out pragmatic recommendations. The interview was digitally recorded to facilitate transcription at a later date (Halcomb and Davidson, 2006). A semi-structured interview containing 5 open-ended questions posed allowed greater opportunities to asking more probing questions (McIntosh and Morse, 2015). Refer to appendix B. Qualitative data obtained was analysed using an interpretivist approach which unlike quantitative data analysis has no standardised tests and is open to an individual's idea of truth and interpretation (Winter, 2000). This process can appear to be purely intuitive but when contrasted against survey data collated, it can produce robust analysis (Bolarinwa, 2015).

PRELIMINARY ANALYSIS

The results of the pilot study revealed that most questions posed were appropriate for the study and easy to read and comprehend. However, two questions produced very similar answers and as a result, one of these questions was discarded from the final questionnaire. Moreover, participants found that the on-line questionnaire was user-friendly and could be readily completed within 5-10 minutes. Consequently, the questionnaire was deemed fit for purpose and the decision was taken to commence the main survey using this data collection instrument.

For the main survey, data was collected over a three week period (between 02/04/2019 to 19/04/2019) and the total number of respondents was 45. Most respondents stated they had pertinent experience with fire safety, with the exception of 4.3% (frequency (*f*) = 2) as noted in Table 4a. This is most likely due to those participants being full-time students at University

which would infer that they have very little or no experience. In terms of participant age, the highest number of respondents were from the 25-34 age group with a 39.1% (f = 18) response rate as shown in Table 4b. Higher interest levels from young to middle aged professionals could be due to the fact that any changes made to regulations would affect them as they are likely to remain in the industry longer than other age groups e.g. 65+. The professional background of participants varied from those of technical and non-technical backgrounds to those of construction and non-construction backgrounds. Table 4c illustrates that surveyors constituted the highest number of responses 32.6% (f =15), which could be attributed to their professions general interest in the field under investigation. Similarly, engineers had a response rate of 28.3% (f = 12), and again this could be due to relevance of fire safety to their profession. The 'other' category had the second largest responses 30.5% (f = 14) - this category includes those of various occupations such as an office manager, finance graduate, computer programmer, scientist and project co-ordinators. It is hypothesised that these professionals received most of their knowledge on the matter from the media which fuelled public outrage, and created urgency in terms of preventing another incident like Grenfell from occurring. Future work is required to prove this theory definitively as such is beyond the scope of this present study.

<Insert Tables 4a, b, and c about here>

MAIN SURVEY AND EXPERT INTERVIEW ANALYSIS

For the two qualitative questions posed (refer to Table 5b), the response received was polarised and there was a 50/50 split that either agreed or disagreed with the first question, namely: "*Do you believe that the response from industry regarding the Grenfell tragedy has challenged the current discourse regarding fire-proofing of buildings?"* It was generally felt that the opposing point of views presented were reflective of what is currently being debated within industry (as fuelled by the media). For example, some argued that the response is rather lack lustre and that:

> *"There is generally always a knee jerk reaction to such a horrible tragedy. We tend to find the legislation is sufficient, but enforcement and management of the supply chain is lacking."*

Others were more extreme and suggested that the industry remains complacent until another tragedy happens. These viewpoints could be attributed to the fact that the last time building regulations relating to fire were updated was almost 14 years ago i.e. Regulatory Reform (Fire Safety) Order 2005. Those who agreed with that statement, suggest that Grenfell did change the discourse as it exposed how 'incompetent' the current system is, some respondents also went onto suggest that:

> *"…it is not expected that fire could spread externally as there is a mind-set that fire risk is unlikely outside the facade of the building."*

Conversely, other respondents felt that the response to Grenfell led to a notable change from both a professional and even a personal stance, viz:

> *"Yes. Grenfell Tower is the latest in a number of under reported fires. However, with its publicity due to the tragic loss of life, safety standards and materials are being re-assessed."*

Overall, the two sides were either quite optimistic or cynical about the response from the industry which suggests that insufficient conversations are taking place as there remains lack of clarity in terms of change. However, it is worth noting that Rt Hon James Brokenshire MP is pushing for a more effective regulatory framework to improve building standards. Brokenshire (GOV.UK, 2018) set out to implement the recommendations made by the Hackitt report.

For the second question, (namely: *"Do you believe that the current curriculums in Higher Education institutes is sufficient in providing the next generation with knowledge on material awareness and fire-proofing buildings?")* the majority 41.31% (*f* = 19) disagreed with the statement and argue that HEI's do not provide the learning necessary to equip young professionals with knowledge on fire safety in buildings. The others either agreed with the statement (28.26% - *f* = 13) or were unsure (30.43% - *f* = 14). One respondent stated that:

> *"Fire safety and importance / implications needs to explored in greater depth within construction technology [modules taught]."*

Another respondent was more direct and stated that:

> *"No, I believe most of these higher education courses provide shallow knowledge. Educational institutions have drifted from equipping students with detailed knowledge and they now just focus on making money. Standards of education are now severely compromised as there many students entering the industry without knowledge. This explains the poor selection and compromise on building materials. Gone are the years of durability and safety. It's all money."*

Perhaps the issue of a notable lack of fire technology education resides in the fact that fire safety in buildings is a specialised area which requires HEI staff to receive further training. Once trained, fire technology could be included as mandatory training for graduates or junior entrants and/or specific courses could be created as a top-up continual professional development for all professionals. Realising this ambition would require support from professional bodies to accredit such courses or insist that fire safety is an integral part of the undergraduate curriculum.

A respondent suggested that a different profession should be used in the industry almost as a *"quality assurance mechanism"* for fire safety in buildings from project inception to post-completion. This void could be filled by facilities management degrees but change in terms of university curriculum is unlikely to occur without legislative and professional body support.

Quantitative analysis

Questions were presented to respondents where they had to rate their opinions using Likert items (refer to Table 5a). Unsurprisingly, most remain neutral or agree with the statement: *"The current regulations regarding fire safety in terms of design and material specification are fit for purpose.*" Notably 34.78% *(f* = 16) agreed with the statement whilst 39.13% *(f* = 18) remained neutral. This is most likely due to conversations about the aftermath of Grenfell mainly happening within the government and between very senior members of the industry. This leaves the rest to find out about regulation changes through their professional networks, which means that the information being exchanged lacks clarity hence, most respondents being neutral.

Relating to the statement: *"Post construction inspections are compliant with current regulations and standards"* most respondents remained neutral at 39.13% (*f* = 18) and this is most likely due to lack of knowledge of building regulations relating to fire. This knowledge is quite specific and generally is not covered by graduate training schemes or even in-company training.

With regards to this statement: *"The channel of communications with residents and constructors regarding concerns about fire-safety should be in a formal system",* 50% (*f* = 23) agreed. This statement comes after the media unearthed the resident's complaints and worries regarding Grenfell tower in terms of fire safety and how they were ignored not only by contractors but also landlords, council and housing association (Hilditch, 2018).

At 36.96% (*f* = 17) most participants agree that: "*Knowledge surrounding fire-safety in the construction industry is inadequate"* - this could reflect on individuals' personal experience of being trained or taught (or rather not taught!) about fire-safety. Linking to this statement, from the earlier responses of question 2 on Appendix A, most respondents expressed that HEIs are not doing enough to educate people on fire safety.

For the statement that: *"Tower blocks can be fire-safe in terms of material and building design"*, the majority agreed 47.83% (*f* = 22) with this statement and there only 4.35% (*f* = 2) strongly disagreeing. This may suggest that on a design and architectural level, high-rise residential buildings can be fire safe with the use of certain materials and fire-rated fittings.

The statement "*The social class & race of the residents was an influencing factor in the neglect and quality of construction materials specified"* generated somewhat slightly opposite responses with those agreeing at 32.61% (*f* = 15) and those disagreeing at 23.91% (*f = 11):*. The media created links between social class and race being factors which allowed neglect to happen in terms of the quality of the material specified and complaints being ignored. This explains why some felt that was a classic example of institutional classism and racism (Snoussi, 2018). But 23.91% felt otherwise which could be due to the respondents' accepting that it was not social factors which led to the disaster but rather the inadequate knowledge and application of fire-safety in high rise buildings. Either way, views on this are polarised and it is hypothesised that the media storm around Grenfell has contributed to a sense of unfairness in some quarters of society and that people have projected their own self-image upon this.

The statement on whether: *"The application of escape methods are taken into consideration when buildings are designed"* generated 50% (*f* = 23*)* agreement amongst sample participants and reflects the fact that escape provisions were inadequate.

Expert interview

Having conducted the main survey analysis, the findings of the analysis were then presented to an expert who had direct involvement in the Grenfell enquiry and hence, had first-hand information and knowledge about the disaster. As an opening comment, they said:

> *"Current building regulations are compliant but I'm not sure if they're good enough. Interestingly there are no specific building regulations for mass evacuations and having spoken to fire services, they are frightened about hospital fires as the patients are not always mobile, making evacuation difficult."*

When we discussed *"are current building regulations effective in terms of design to allow escape?"* in terms of Grenfell, the expert stated that:

> *"Although tower blocks must be fitted with fire-rated systems and even firefighting stairs, the difficulty of escape due to narrow corridors and even the number of stair flights could dramatically affect the number of survivors."*

Grenfell tower was approximately 24 storey and no-one on the 24th storey escaped. It is very difficult to manoeuvre through a building engulfed by smoke and fire in the dark from the highest floors. This suggests that although there is consideration to fire escape, it does not consider large numbers of people on a multi-storey building. However, on a positive note the expert claimed that:

> *"…in private housing accommodations, often two sets of escape staircases are provided even though this is not a requirement from building regulations."*

From this observation, it would appear that the Building Regulations provide a minimum level of conformance but practitioners are at their discretion to exceed this minimum threshold if desired. Such is probably not common practice due to additional costs that this 'best practice' is also expensive.

For a while now many have expressed that changes must be made and implemented through legislations and when asked: *"How confident are you that legal changes will happen & describe difficulties that may or may not occur when implementing changes?",* the expert argued that the Hackitt report can potentially start both legal and cultural change within the industry and that:

> *"this [the Hackitt Report] can have a domino effect on aspects of construction including procurement and supply chain management [which can help control quality right from the source]."*

When asked: "*From a business stance, how would changes in building regulations work and if they carry liability would those changes be embraced*?", the expert argued that the single most problematic change would be the Hackitt review's "*advocation for responsibility of life"* namely from initial design stages. This would mean that architects would have to accept responsibility of life when creating designs for high-rise buildings. The expert stated that there will be reluctance from a commercial point of view and this role could include liabilities but said that until there is further clarification:

> *"it is unlikely that many would be on-board with this recommendation."*

From the quantitative question responses on whether HEI's are doing enough to educated those in the wanting to join the industry, the majority argued that this was not the case. However, the expert felt they could not answer that question as they were unsure of HEI curriculums on fire safety. When asked *"Do you believe that a new profession should be created to take the role of fire safety in construction?",* the expert suggest that instead of creating a new profession the role could be adopted by an existing one:

"Facilities management could potentially include HSE of occupancy and fire safety as a part of their services."

From this statement, it may be worth categorising fire-safety knowledge as a specialist form of training or a course on its own which should then be made compulsory for practitioners of all levels to ensure that they are equipped with knowledge that could prevent another Grenfell from happening.

CONCLUSIONS

This research project took a novel approach to investigate the construction industry's view on the effect and aftermath of fire in high-rise buildings. Specifically focusing on two areas: the practitioner~~'~~s' understanding of fire safety design, material specification, construction and maintenance of high-rise rise blocks throughout a building's life cycle; and the current professional attitudes towards fire-proofing. Considering how recent the Grenfell tragedy was, there is only a limited amount of research available that is based upon the sociological views of why the tragedy happened i.e. was it classism, or was it simply based on the construction technology of the tower block i.e. the cladding. However, it is apparent that this disaster has numerous actors, interventions and political agendas that make the creation of a singular hypothesis difficult to derive. Indeed, it is most likely that a toxic combination of various factors (each contributing to an iterative chain of events) was responsible for the Grenfell tragedy. As a result, i~~I~~t is far more likely that a larger study will be needed to generate a series of interlinking theories and hypothesis that will require~~ing~~ testing in practice. Whether a totally objective view can be acquired (given the associated complexity and influence of the press upon public opinion) remains to be seen but such work is worthy of future pursuit.

Despite these challenges, ~~The results from the research illustrate~~anecdotal evidence suggests that the Grenfell disaster (and ensuing media storm) has raised the general level of knowledge and competency regarding fire safety amongst construction professionals. However, this research posits that there is still much improvement to be made as a large proportion of survey participants indicated ~~equally many perceive~~ that the industry is still ~~to be~~ lacking an adequate understanding of fire safety in general. Consequently, a clear polarisation in perspectives prevails. Viewpoints from practitioners', students and extant literature go on to further suggest that not only is there a lack of knowledge and understanding of fire safety in terms of design, material specification and maintenance but there is a lack of provisions available to gain training in this field. To overcome this, it has been suggested that there should be specialist training available to all those who are in the industry whilst making necessary improvements to HEIs' curriculums to provide students with comprehensive all-round~~ed~~ knowledge. Given that this is a specialist area of study, HEIs and colleges may need to consider employing visiting lecturers or specialist industry practitioners (e.g. fire safety engineers) to cover fire safety content until future generations of construction practitioners are sufficiently trained to pass that knowledge acquired on themselves.

It is also apparent that the discourse surrounding Grenfell has been heavily influenced by mainstream media coverage which was generally very negative and a plethora of evidence from the research suggests that many believe the current regulations to be not fit for purpose - leading to calls for regulatory reform as well as a push for a wider framework change through legislation.

These emotive calls can be unhelpful and lead to kneejerk reactions vis-à-vis the development of a more holistic solution that covers: fire technological developments; education and training of construction professionals; and improvement in current regulatory guidance and enforcement. Arguably therefore, a period of calm and considered reflection is advisable as any changes made will have long-lasting ramifications – hence, the importance of securing optimised solutions.

Despite challenges posed, the initial research has served to better define the magnitude of the problem and enhance the knowledge base of the field. Yet, it is also apparent that further research is needed, namely to: i) measure the perceptions of a wider pool of respondents - including the views and opinions of residents themselves; ii) create a pragmatic design, construction and maintenance of buildings strategy to ensure that all stakeholders within the building's whole life cycle (including architects, contractors, facilities management teams and occupants) are on-board and effectively collaborate to apply the recommendations made in the Hackitt report; iii) work with professional accreditation bodies and Universities to reform existing HEI curriculum on fire safety whilst providing training for those already in the industry. Revised content should include materials on the latest technological developments in design and construction for fire as well as guidance on how to apply prevailing regulations and international standards; and iv) investigate whether or not the government's funding in fire-safety is being effectively deployed.

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Table 1 - Fire safety guidance in UK (A guide to fire safety and performance in fire, 2018)

Country	Regulations	Guidance
England and Wales	Building Regulations (2)	Approved Document B
Scotland	The Building (Scotland) Regulations 2004 (3)	Technical Handbook (Section Fire)
Northern Ireland	The Building Regulations (Northern Ireland) 2001 (4)	Technical Booklet E

Table 2 – Passive and Active Fire Systems

System Type	Description	Citations
Passive Systems		
Dampers	Opening protection used in fire barrier openings	(Buildings.com, 2018)
Photo luminescent egress	Fire exit signage	(Marsden-fire-safety.co.uk, 2018)
Barriers	Fire barriers including fire rated doors, walls, floors and ceilings	(Buildings.com, 2018)
Active Systems		
Smoke alarms	Detect smoke and fire	(Hse.gov.uk, 2018)
Extinguishers	Water, powder, foam or CO2	(Burton, 2018)
Sprinkler system	Water or spray system	(Hse.gov.uk, 2018)

Figure 1 - Timeline of Fire Safety Legislations/Regulation Events (Rla.org.uk, 2018)

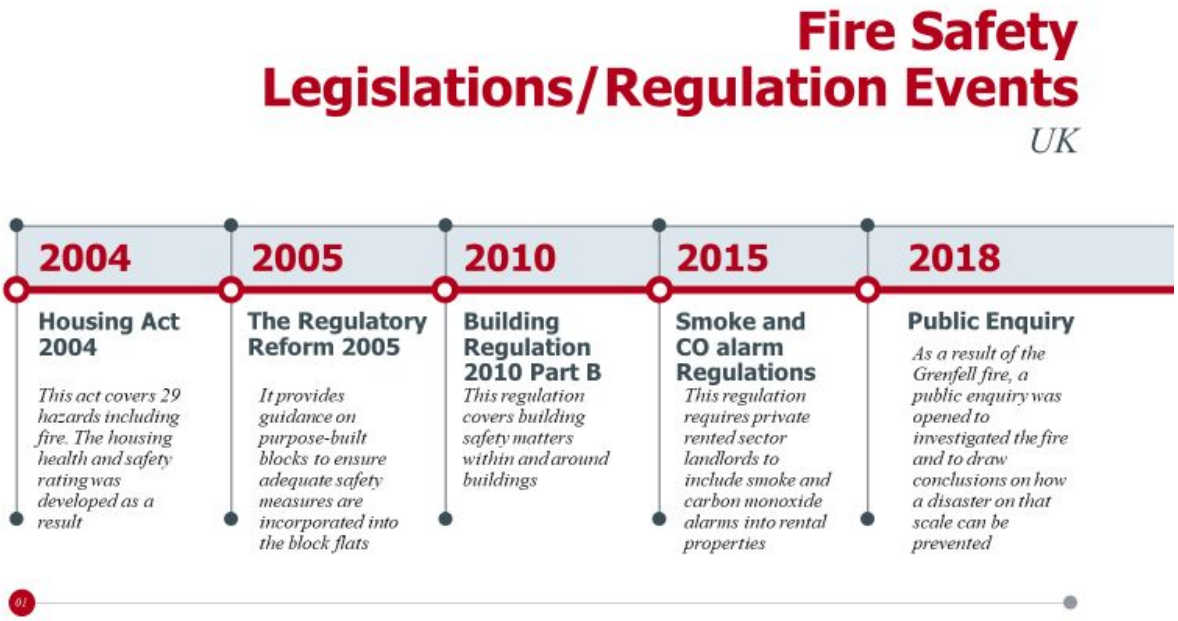

Table 3 – Hackitt Report Findings, (Hackitt 2018)

RECOMMENDATIONS	DESCRIPTIONS
NEW REGULATORY FRAMEWORK	The new framework applies to high rise residential properties (10 storeys or higher) Local planning authorities must identify and report new high rise residential properties at risk to the regulator. Existing buildings must be identified through other means and reported to regulators.
NEW JOINT COMPETENCY AUTHORITY	The purpose of the authority is to maintain a 'database' of all high rise buildings at risk and their key duty holder. For new builds, the duty holder should ensure building safety risks a mitigated at the design and construction phase. Existing buildings must have periodic safety review to reduce ongoing building safety risks. The duty holder must be on top of safety tests and have annual reports of all passes and fails. Residents must be engaged and when concerns are raised, the duty holder must request a test to identify and understand the risk. Strive to meet the outcome based goals set by regulations.
MANDATORY INCIDENT REPORTING MECHANISM	The mandatory occurrence reporting system currently used by the Civil Aviation Authority, applied on a compulsory bases where all incidents have to be reported avoiding the issue of blame.
GIVING RESIDENTS A VOICE	This mechanism is intended to give power and reassurance to residents by allowing: greater transparency of information on building safety; more involvement in decision making. This recommendation could be applied through the support of resident's associations and tenant panels. To better manage complaints they can be forwarded to an independent statutory body that can provide assistance where service providers have failed to make appropriate changes at no risk to the residents themselves
PRODUCTS	Following the faulty cladding system on Grenfell tower, a new regime providing more effective testing with better labelling and clear traceability should be driven into industry. Regular intervals of product testing should drive improvement of product standards and performance which is hoped to encourage better quality assurance. "This regime would be underpinned by a more effective market surveillance system operating at a national level".
PROCUREMENT	To integrate roles and responsibilities with a mind set to achieve "high safety, low risk" options and the that the whole life cycle cost is considered when procuring a building to not prioritise short-term cheap with long term maintenance options.

Table 4a – Years of experience

Experience	Frequency (Number)	Percent %
No Experience	2	4.3
≤ 5 years	18	39.3
6-9 years	10	21.7
10-14 years	6	13
15-19 years	3	6.5
≥ 20 years	7	15.2
Total	46	100

Table 4b – Age of participants

Age group	Frequency (Number)	Percent %
Under 18	0	0
18-24	10	21.7
25-34	18	39.1
35-44	11	23.9
45-54	4	8.8
55-64	3	6.5
65+	0	0
Total	46	100

Table 4c – Profession of participants

Profession	Frequency (Number)	Percent %
Surveyor	15	32.6
Construction Manager	2	4.3
Engineer	12	28.3
Construction Academic	2	4.3
Other	14	30.5
Total	45	100

Table 5a - Responses

Questions	Number of Respondents (No.) *Likert Item Ratings and (% frequency)*				
	1	**2**	**3**	**4**	**5**
"The current regulations regarding fire safety in terms of design and material specification are fit for purpose."	1 (2.17%)	16 (34.78%)	18 (39.13%)	7 (15.22%)	4 (8.70%)
"Post construction inspections are compliant with current regulations and standards."	4 (8.70%)	11 (23.91%)	18 (39.13%)	12 (26.09%)	1 (2.17%)
"The channel of communications with residents and constructors regarding concerns about fire-safety should be in a formal system."	16 (34.78%)	23 (50.00%)	5 (10.87%)	2 (4.35%)	0 (0.00%)
"Knowledge surrounding fire-safety in the construction industry is inadequate."	4 (8.69%)	17 (36.96%)	14 (30.43%)	9 (19.57%)	2 (4.35%)
"Tower blocks can be fire-safe in terms of material and building design."	16 (34.78%)	22 (47.83%)	4 (8.69%)	2 (4.35%)	2 (4.35%)
"The social class & race of the residents was an influencing factor in the neglect and quality of construction materials specified."	8 (17.39%)	15 (32.61%)	5 (10.87%)	11 (23.91%)	7 (15.22%)
"The application of escape methods are taken into consideration when buildings are designed."	9 (19.57%)	23 (50.00%)	6 (13.04%)	6 (13.04%)	2 (4.35%)

Table 5b- Responses

Questions	Number of Respondents (No.) *Score and (% frequency)*		
	Yes	**No**	**N/A**
"Do you believe that the response from industry regarding the Grenfell tragedy has challenged the current discourse regarding fire-proofing of buildings? Yes or No?"	16 (34.78%)	16 (34.78%)	14 (30.43%)
"Do you believe that the current curriculums in Higher Education institutes is sufficient in providing the next generation with knowledge on material awareness and the fire-proofing of buildings? Yes or No."	14 (30.43%)	19 (41.31%)	13 (28.26%)

APPENDIX A – QUESTIONS POSED

No.	Type	Questions posed
1	Qualitative	Do you believe that the response from industry regarding the Grenfell tragedy has challenged the current discourse regarding fire-proofing of buildings?
2	Qualitative	Do you believe that the current curriculums in Higher Education institutes is sufficient in providing the next generation with knowledge on material awareness and fire-proofing buildings?
3	Quantitative - Likert item (1-5)	The current regulations regarding fire safety in terms of design and material specification are fit for purpose.
4	Quantitative -	Post construction inspections are compliant with current regulations and standards.
5	Likert item (1-5)	The channel of communications with residents and constructors regarding concerns about fire-safety should be in a formal system.
6	Quantitative -	Knowledge surrounding fire-safety in the construction industry is inadequate.
7	Likert item (1-5)	Tower blocks can be fire-safe in terms of material and building design.
8	Quantitative -	The social class & race of the residents was an influencing factor in the neglect and quality of construction materials specified.
9	Likert item (1-5)	The application of escape methods are taken into consideration when buildings are designed.

APPENDIX B- EXPERT INTERVIEW QUESTIONS

No.	Type	Questions posed
1	Qualitative	Do you believe that the response from industry regarding the Grenfell tragedy has challenged the current discourse regarding fire-proofing of buildings?
2	Qualitative	Are current building regulations effective in terms of design to allow escape?
3	Qualitative	How confident are you that legal changes will happen & describe difficulties that may or may not occur when implementing changes?
4	Qualitative	From a business stance, how would changes in building regulations work and if they carry liability would those changes be embraced?
5	Qualitative	Do you believe that a new profession should be created to take the role of fire safety in construction?