BUILDINGS AS COMPLEX SYSTEMS:

IMPLICATIONS AND CHALLENGES FOR SAFETY MANAGEMENT AND REGULATIONS

INTRODUCTION

Building safety is a topic of utmost importance considering the potential catastrophic outcomes of safety failures for occupiers, owners and professionals involved in the delivery and operations of the building. Building regulations are the main means through which building safety is assured but despite the widespread use of building regulations globally, serious safety failures continue occurring in buildings (e.g. Structural Safety 2019; Kodur et al. 2020; Fire Safe Europe 2021); thus, resulting in attempts for regulatory reforms worldwide (The World Bank 2013). A common principle underpinning most of these attempts is the adoption of a 'risk-based approach' (Black 2010), which suggests regulating building safety based on a classification of safety risk-level. Such an approach typically considers the factors such as the size, design features, construction methods, and final use/operations of the building (The World Bank 2013). Thus, high-risk buildings are associated with complex technological (e.g. building design, materials, and methods) and social (e.g. the number and interdependencies of the stakeholders) aspects (Hills 2018; Hackitt 2018). As a result, there has been a recognition that, when it comes to assuring safety, high-risk buildings need to be considered as complex systems, "where the actions of many different people can compromise the integrity of that system" (Hackitt 2018, p. 6).

A conception of high-risk buildings as complex systems has implications on the way in which building safety must be understood, managed, and regulated. Complex systems theory suggests that the safety in a complex system needs to be understood holistically, rather than as the sum of its parts, because it is an emergent property resulting from the complex interactions and relationships (Dekker et al. 2011). However, currently, the academic literature, professional expertise and regulations on building safety are fragmented, focusing on different project phases (e.g. design, operations), technical expertise (e.g. architecture, structural design, fire safety), building technologies (e.g. façade systems, doors), and stakeholder groups (e.g. designers, building owners, operators) – mirroring the fragmented organisation of a building's life cycle (Latham 1994; Pitt and Hinks 2001; Alashwal et al. 2011). Therefore, there is a need to explore how the safety of high-risk buildings could be approached holistically, as complex systems, through a life cycle approach, and the role the building regulations could play to enable this.

Research on high reliability organisations (HRO) (Weick et al. 1999, Weick & Sutcliffe 2007) provides a holistic framework to explore these questions by advocating for an understanding of safety as an organisational outcome, which cannot be reduced to the sum of the safety of the distinct social or technological components of the organisation. Originating from the observations of organisations in extremely safety-critical industries, such as petro-chemical and nuclear, HRO offers a framework that emphasises complexity as a characteristic of the entire organisation (i.e. organisation as a complex system) in order to ensure safe outcomes from complex interactions and relationships between people and technologies. In particular, the idea of collective mindfulness (Weick et al. 1999, Weick & Sutcliffe 2007), which is rooted in organisational culture (Weick 1987), provides an understanding of how organisations can deal with such complex interactions to reliably prevent catastrophic safety failures.

This paper uses HRO literature as a lens to explore the empirical setting of the undergoing regulatory reform in the UK, which aims to establish a holistic life cycle approach for managing the safety of high-risk residential buildings as complex systems, following the Grenfell fire (MHCLG 2020). Ten semi-structured interviews were conducted with different actors who engage with fire safety related issues in construction project delivery and operations in the UK. The interviews explored the interviewees' opinions about, and their experiences with, the planned and already implemented regulatory changes to reveal the cultural aspects of the organisation of the building life cycle. The data is analysed through a qualitative abductive process which included an initial stage of inductive thematic analysis, followed by a deductive stage of defining and naming those themes with considerations from HRO literature. The findings expose some of the persistent perceptions and associated practices that drive safety-related behaviour through the life cycle of high-risk buildings with references to both before and after the regulatory changes. Thus, they reveal some of the cultural aspects of the organisation of the building life cycle, which are incompatible with those that underpin HRO and collective mindfulness. Furthermore, the identified cultural aspects also enable a critical discussion of the proposed regulatory changes, which highlight the need for coherence between the regulations and organisational culture. The conclusion calls for future regulatory, practical and research efforts to develop a better appreciation of the cultural issues in the organisation of the building's life cycle, and to aim for measures that would cultivate an organisational culture that would enable collective mindfulness.

HIGH RISK BUILDINGS AS COMPLEX SYSTEMS

Safety of a building is determined by the interdependent decisions and actions taken by a variety of stakeholders during the interrelated phases of design, construction and operations/occupation; however, there has been a lack of research studying building safety holistically, from a life cycle perspective (Yau et al. 2008). The majority of the academic and regulatory literatures concerning building safety mainly focus on individual types of safety hazards (e.g. fire safety, structural safety) and phases (e.g. fire safety of design, emergency response in case of a fire) (Maluk et al. 2017; MHCLG 2010); and lacks such a holistic view that acknowledges the strong interrelationships between various subsystems and overall building performance (Meacham 2016).

Besides, the literature that associates high-risk buildings with complexity sometimes provide a rather simplistic, technology-focused view of complexity. For example, in the context of building control, RICS (2020) highlights the technological complexity, and suggests that a complex building is "where the approach to design and construction adopts more complex approaches, as opposed to following the minimum standards suitable to common circumstances as set out in [common building regulations] guidance…" (p. 111). However, other literature that considers 'buildings as complex systems' aptly emphasises that social interactions that characterise the design, delivery/installations, and occupation/operations (i.e. the life cycle) must be recognised as a key part of the complexity (Schalcher 2010; Meacham 2016; Hackitt 2018). As stated by Hackitt (2018), the complexity of high-risk buildings is related to the fact that the actions of numerous people involved in the building's life cycle can compromise the integrity of the building.

The conception of high-risk buildings as complex systems, where complex technology and social relationships co-exist, implies that there is no longer a definitive relationship between the behaviour of individual constituents (i.e. specific building technologies or stakeholders) and the safety outcomes of the system (i.e. the building). Rather, technological, and social issues must be understood as the interacting parts of an organisational whole, which together determine the performance of the system (Perrow 1984, Reason 1997, Allocco 2010). Hence, it can be argued that, in the context of safety of high-risk buildings, it is the organisation of the building life cycle (with all its social and technological constituents) that needs to be understood as a complex system.

Such organisations, which exhibit behaviour of complex systems (complex organisations henceforth), have been researched extensively in management and safety research. A complex organisation consists of various social and technological entities that interact in ways that produce non-linear, path-dependent, and at least to some extent unpredictable, outcomes (Maylor et al. 2008; Aven & Ylönen 2018). As each entity in a complex organisation is local, in the sense that it is limited in its situational awareness of the entire system, the behaviour of such a system is not amenable to traditional systems analysis, which rely on the regularity of interactions, separability of elements, and the presence of clear cause-and-effect relationships (Maylor et al. 2008; Dekker et al. 2011).

For this reason, complex organisations have widely been associated with safety failures that cannot be attributed to specific human- or technology-related errors (Perrow 1984). Rather, in complex organisations, safety failures occur due to an unfolding series of situations through which social and technological issues are interweaved involving, for example, technology failure, human errors, lack of communication within and between organisations, inappropriate regulation, etc. (Reason 1997, Allocco 2010). Thus, in such settings, situations can arise where nobody has a full understanding of, or the full authority or the means of intervention on, the developing safety hazards (Perrow 1984). Therefore, understanding safety in complex organisations requires a recognition of the often-conflicting safety considerations of multiple stakeholders involved (Dekker et al. 2011).

In safety science, this recognition has led to a shift away from safety management through bureaucracy, which focuses on the measurement of static indicators, such as KPIs, (Dekker 2014) and quantified risk (Aven & Ylönen 2018), as well as the use of regulations, and root cause analysis of accidents, towards a focus on the social conditions and the organisations' strategies and abilities to cope with complexity (Haavik et al. 2019). The need for a focus on social and organisational issues is also implied in the context of high-risk buildings by Hackitt (2018), who claimed that "we need to adopt a very different approach to the regulatory framework covering the design, construction and maintenance of high-risk residential buildings which recognises that they are complex systems where the actions of many different people can compromise the integrity of that system" (p. 6). High reliability organisations (HRO) literature, which is one of the main schools of thought that adopt such a focus, is introduced in the next section to be later used in the paper as the interpretive framework for the analysis and discussion.

HIGH RELIABILITY ORGANISATIONS

Literature on high reliability organisations (HRO) is one of the main schools of thought that focus on the social and organisational underpinnings of system safety and accident prevention in complex organisations (Lekka 2011). Based on the observations on extremely safety-critical settings (e.g. nuclear plants, air traffic control), HRO researchers argue that it is possible to achieve a consistent record of safety over long time periods through some organisational measures that effectively prevent and contain catastrophic errors (Lekka 2011; Roberts 1990; LaPorte & Consolini 1998). In HRO literature, the five processes of 'mindful organising', which enable 'collective mindfulness' (Weick et al. 1999; Weick & Sutcliffe 2007), have been widely accepted as objectives to be achieved to effect high reliability for an organisation (Cantu et al. 2021). These five processes are 1) preoccupation with the avoidance of failure, 2) reluctance to simplify interpretations, 3) sensitivity to operations, 4) commitment to resilience, and 5) under-specification of organisational structures (Weick et al. 1999).

'Pre-occupation with failure' refers to the need for noticing, taking seriously, and learning from, the process or system lapses, which should be treated as the symptoms of safety issues (i.e. weak signals). 'Reluctance to simplify interpretations' refers to an organisation-wide awareness that the processes are interconnected, and so, anything that is 'out of the ordinary' needs to be further examined, and intervened in if necessary, as soon as it is discovered, before it builds up into a bigger problem. 'Sensitivity to operations' highlights the importance of maintaining a situational awareness during operations because even routine operations involve variations from one time to another, and such variations might trigger a hidden system interaction that can quickly cascade into a larger problem if not recognized and intervened early. ‘Commitment to resilience’ refers to the organisational ability of detecting, containing, and bouncing back from, unpredictable disruptions before they disable operations or develop into major safety hazards. Finally, ‘under-specification of structures’ highlights the necessity of prioritising subject expertise over hierarchical, or otherwise (e.g. social, political etc.), authority and power, when dealing with developing conditions that create safety hazards.

Culture of reliability

Weick et al. (1999) emphasise that ‘collective mindfulness’ is less about decision making and more about inquiry and interpretation grounded in capabilities for action, which suggests that achieving high reliability through ‘collective mindfulness’ is a matter of organisational culture (Weick 1987; Pidgeon & O’Leary 2000; Nævestad 2009; Schulman 2020). According to Pidgeon and O’Leary (2000) organisational culture is intimately related to how people make meaning, and so, it encompasses the symbols and systems of meaning through which a given group understand the world. It follows from this that, from a safety point of view, culture is the set of assumptions and their associated practices, which serves to construct a particular version of risk, danger and safety (Pidgeon and O’Leary 2000).

Weick (1987) highlights two important roles of organisational culture for dealing with safety in complex organisations: 1) culture as a means for sense-making under complexity; and 2) culture as a means for coordination at a distance under complexity. First, because culture underpins meaning making and interpretation, it determines how ill-structured situations are understood in the first place within the dynamic environments of complex systems, which provides the premises for subsequent decisions. This means that the shared beliefs and expectations in a complex organisation determines how the organisation simplifies its environment to make sense of what the hazards are and what precautions are appropriate

(Weick & Sutcliffe 2007; Nævestad 2009). When there is discrepancy between the organisation's 'taken for granted' beliefs and assumptions for dealing with hazards, and a worsening but ill-structures state of affairs, warning signs that could be otherwise noticed and acted upon are ignored, thus, leading to potentially catastrophic safety failures (Turner 1978; Nævestad 2009).

Second, culture is crucial for coordinating action at a distance without imposing tight bureaucratic centralisation through standard operating procedures, which are unable to effectively deal with non-standard (i.e. unpredictable, emerging) behaviour of complex systems (Derek 2014). According to Weick (1987) both centralisation and decentralisation are crucial for high reliability organisations to deal safely with the complex behaviour, and culture is the major enabler for harnessing both the benefits of centralisation and decentralisation at the same time. In Weick's (1987) words:

> "… [Culture] creates a homogeneous set of assumptions and decision premises which, when they are invoked on a local and decentralized basis, preserve coordination and centralization. Most important, when centralization occurs via decision premises and assumptions [i.e. via culture], compliance occurs without surveillance. This is in sharp contrast to centralization by rules and regulations or centralization by standardization and hierarchy, both of which require high surveillance" (p. 124).

Furthermore, Weick (1987) also makes the argument that centralisation through neither rules nor standardization are well equipped to deal with situations for which there is no precedent, which are to be expected in complex systems such as high-risk building projects. On a parallel note, Schulman (2020) emphasises the importance of achieving a coherence between the formal organisational structure and culture to reliably assure safety, and explains that for each formal structural element, such as roles, rules, communication links as well as accountability and authority, there are likely to be shadow cultural elements that can reinforce/support or undermine/contradict those formal arrangements. Hence, the decisions about the formal organisational structure (i.e. centralisation or decentralisation of authority and communication, density of formal rules etc.) requires a deep appreciation of both local and system-level cultural perspectives on the work and safety (Schulman 2020).

Finally, Schulman (2020) also discusses the cultural elements of HROs that enable reliable safety through an absolute prioritisation of safety. According to Schulman (2020) one of these elements is a sense of responsibility for all types of safety hazards and a personal identification with safety which make people think and care about safety beyond their immediate departments/daily works. Schulman (2020) argues that, in HROs, a culture that supports and protect such attitude and people is crucial not only to spread it to the entire organisation but also for preventing the competing organisational values, such as efficiency, cost reduction or speed in completion of tasks, to be prioritised over safety under any condition. Another value of HROs is an attitude of scepticism in terms of what might go wrong, which is crucial for detecting uncertainty and potential errors in measures, models and assumptions. Moreover, according to Schulman (2020), HROs develop, believe in, and rely on "precursor" strategies that identify conditions or states that, while not failures or accidents in themselves, can lead through chains of causation to more direct failure causes. The idea of having such precursor strategies stems from an acknowledgement that the behaviour of complex systems is emergent. So, when one or more circumstances are perceived to be moving outside the routine conditions of operation or organisation, then the operations would be ceased until the new circumstances are better understood or they return to the routine conditions of operation.

This literature review suggests that when high-risk buildings are seen as complex systems, collective mindfulness is required to reliably prevent catastrophic safety failures. HRO literature suggests that organisational culture, which guides meanings and enable coordination at distance in complex organisations, is a key element for the enactment of collective mindfulness. Hence, this research explores the organisational culture that drives the safety-related behaviour in building life cycle from the lens of HRO literature to develop insights on how safety of high-risk buildings could be approached and regulated effectively.

METHODOLOGY

Research approach

The research adopts an abductive approach (i.e. abductive reasoning and research process) (Kovacs & Spens 2005) to explore how safety of high-risk buildings could be approached holistically to cope with the complexities involved in its life cycle, and the role the building regulations could play to enable this. In simple terms, abductive reasoning refers to the reasoning from an observation to possible explanations (Aliseda 2007). The use of abductive reasoning in research is often justified when there is a lack of established theories to explain the observation (Awuzie & McDermott 2017). Thus, abductive reasoning works through interpreting or re-contextualising phenomena from the perspective of a new conceptual framework in an attempt to explain the observation, or to understand something in a new way to generate new insights (Dubois & Gadde 2002). In the context of this research, previous literature on building safety suggests that the life cycle of high-risk buildings present complex technological and social issues which are significant for the management and regulation of safety. However, there are not any established theories of building safety or high-risk buildings as complex systems. Hence, this research draws upon complex systems theory and the associated safety science literature, particularly HRO literature and the concept of collective mindfulness, to develop insights on the safety management and regulation of high-risk buildings.

Research design

The empirical inquiry aims to explore the culture that drives the safety-related behaviour in the organisation of the building-life cycle to evaluate it from the lens of HRO literature, particularly the cultural underpinnings of collective mindfulness. The design of the empirical inquiry is informed by an interpretive view of organisational culture. This sees culture as an emergent social phenomenon driving the human behaviour and underpinned by norms, attitudes, beliefs/assumptions and perceptions (i.e. culture as something an organisation 'is') (Smircich 1983). Under this view, organisational culture can be conceived as the pattern of assumptions developed by a group as it learns to adapt to its environment. Hence, the culture is the framework for cognitions and behaviours in response to problems (Schein 1990). From a safety point of view, this corresponds to an understanding of culture that is continuously recreated in practice as the members of the organisation behave and communicate in ways which seem to them to be natural and obvious for accomplishing their work, thus, serving them to construct a particular version of risk, danger and safety (Pidgeon and O'Leary 2000).

The UK is selected as the empirical setting due to the undergoing reform to the building safety regulatory regime, where the aim is to establish a holistic life cycle approach for managing the safety of high-risk residential buildings as complex systems, following the Grenfell fire (MHCLG 2020). Inquiring into this setting of change through semi-structured interviews allowed the research to capture some of the deeply rooted attitudes and perceptions present in the organisation of the building life cycle, thus enabling insights into the culture that drives the safety-related behaviour (Glendon & Stanton 2000). Semi-structured interviews were used because of their exploratory strength in terms of capturing various perceptions of the interviewees on the studied regulatory changes whilst still allowing other lines of enquiry to emerge during the interviews (Blandford et al. 2016).

Ten semi-structured interviews were conducted with different actors who engage with fire safety related issues in construction project delivery and operations in the UK. The interviewees were selected through purposive sampling using the criterion that they were representative of the variety of actors involved with building delivery and operations at different points of building life cycle. They were all considered to have the necessary expertise to supply useful and perceptive comments on some, or all, of the questions (Rowley 2012). Table 1 sets out the list of interviewees with each respondent being given a descriptive name to preserve their anonymity. The interview questions focused on revealing the ways in which interviewees perceive/apply the planned/implemented fire safety regulatory changes. The interviewees were asked to disclose not only their part in the decision-making process and any changes to the process as recommended by the independent investigation of the Grenfell fire (Hackitt 2018), but also the changes to their data sources / documents, communication with others and courses of action. The interviews took between 45-60 minutes to complete and reflexive notes recording the researcher's initial thoughts were logged at the completion of each interview. Transcripts of the interviews were produced and checked against the recordings to ensure that they represented a verbatim record of the interview.

The data were analysed using Braun and Clarke's (2006) six steps process of reflexive thematic analysis (TA). The steps are 1) familiarisation with the data, 2) generating initial codes, 3) searching for themes, 4) reviewing themes, 5) defining and naming themes, 6) producing the narrative. Though the steps are sequential, qualitative analysis is an inherently recursive data interrogation process, so the overarching themes were identified by moving back and forth between the steps. NVivo12Pro was used to support the organisation and identification of patterns within the data. Importantly, in line with the abductive research process, the analysis involved an initial inductive stage (Steps 1-4) followed by a deductive stage (Steps 5 and 6). In the first stage (Steps 1 to 4), the emerging themes (patterns of meanings) were identified, which highlighted the perceptions about the impacts of the regulatory changes, within and across individual transcripts (Braun and Clarke 2006). Patterns in the data were identified through a rigorous process of familiarisation with the data, coding, and theme development. This first stage was not wedded to any specific theoretical or epistemological position; a data-driven inductive approach was taken (Braun and Clarke 2006). Overall, 92 preliminary codes were created with 738 extracts of data which were put into five draft theme piles to establish a provisional relationship between the codes, themes, and sub-themes which related to the implications of the planned and recently implemented changes in fire safety regulation (Step 3). The codes included both changes in fire safety documentation (e.g. the creation of the new fire and emergency file) and changes in the regulatory oversight process such as the creation of the Building Safety Regulator and the new regime of duty holders. At this point, the five candidate themes and associated codes were reviewed so that they were meaningful and clear and distinct from each other (Patton 2002) reducing the number of themes to three as shown in FigureXXX (Step 4).

Step 5 is about defining and naming each of the previously identified themes, and this involves describing what is interesting about the theme (in terms of the research questions), and why, as well as identifying the story that the theme is telling (Braun and Clarke 2006). Therefore, it is at this point that the analysis took a deductive turn to interpret the findings from the lens of the theoretical perspective presented in the literature review. Thus, at Steps 5 and 6, the previously identified themes (see Figure XXX) were defined and named to expose the different perceptions and attitudes that the various interviewees had on the same topic. Here briefly explain what theme has been named as what, and why-how! This revealed insights about the culture that drives the safety-related behaviour in the organisation of the building life cycle, which enabled the research to critically discuss those insights from the lens of HRO literature. In the following first the empirical setting is described briefly to provide the background information for the analysis, which is followed by the presentation of findings.

THE EMPIRICAL SETTING: POST-GRENFELL FIRE REGULATORY REFORM IN ENGLAND

Historically, the regulation of fire safety has been informed and shaped by tragic disasters that have consequentially led to significant regulatory reform (Spinardi & Law 2019). One such tragic incident took place in London, UK during 2017. A fire broke out at Grenfell Towers, a 25-storey high-rise residential block of flats, which tragically caused 72 deaths and a further 72 non-fatal injuries. This tragic event created an international awareness of the need to reconsider the management of fire safety in construction project life cycles with countries such as Finland and Denmark introducing new regulations on fire safety. In the aftermath of the tragedy, the UK government commissioned a report, known as the Hackitt Review (2018), to identify the failures in the regulatory regime that led to the tragic incident at Grenfell and to provide robust recommendations for reform.

The review has a specific focus on the application of building regulations and safety to high-risk residential buildings and the need to provide assurance to residents that the buildings they live in are safe and will remain safe. Hackitt (2018) stated that the current regulatory system for ensuring safety in high-risk and complex buildings is not fit for purpose and that a radical overhaul was required of the culture of the construction industry and the effectiveness of the regulators.

The reasons for this systemic failure of the regulatory system were multiple. The guidance provided was complex and impenetrable for the user, and roles and responsibilities were unclear. There was no differentiation in the competency requirements for those who worked on relatively simple, straightforward buildings and for those who worked on high-risk complex buildings. Compliance was weak and enforcement and sanctions were virtually non-existent, while the system of product testing did not provide meaningful quality assurance. Hackitt has stressed that a new regulatory framework needs to be created *'which will drive a real culture change'* (p.6) within an industry that has been contextualised by its ignorance, indifference, and failure to learn from other sectors. The end goal is that fire safety is to be prioritised and addressed on a holistic basis by all actors involved in the development, construction, maintenance, and occupation of high-risk residential buildings.

Although some regulatory amendments have been made soon after the Grenfell fire, such as the bans on external cladding materials and restrictions on the use of desktop studies for the fire test BS8414, the details of the regulatory reform followed the independent investigation (Hackitt 2018) and an industry-wide consultation. Eventually, the UK Government accepted all the 53 recommendations of the Hackitt's (2018) review in their implementation plan (MHCLG 2018). This was followed by the draft Building Safety Bill (MHCLG 2020), which was published in June 2020 to take forward the proposed reforms to the building regulatory system. The new regime adopts a very different approach which recognises that high-risk residential buildings are complex systems where the uncoordinated actions of the different actors can compromise the integrity of the system. Therefore, the core of the proposed legislation is the introduction of formal roles and responsibilities for new duty holders to ensure accountability and allocate risk appropriately. (Phillips & Martin 2021)

The draft bill also provides formal structural rules for the consideration and approval of safety information at key gateway points during the development process and prior to occupation by the new role of Building Safety Regulator. It is proposed that this 'golden thread of building information' will provide the key that links the design intent with the safe occupation of the building, and that Building Information Modelling (BIM) will be used as the suitable digital platform for the knowledge transfer across the phases of the building life.

FINDINGS

In this section we present the findings of the analysis based on the three themes that were defined as: ‘perceptions around safety information, ‘fitness for purpose’ and ‘perceptions of risk’. This reveals some of the perceptions/attitudes and associated practices that drive the safety-relate behaviour in the organisation of the high-risk buildings’ life-cycle in the studied empirical setting.

Theme one: Perceptions around safety information

Under the proposed regulatory framework, duty-holders will be responsible for creating and maintaining the golden thread of building information related to fire and structural safety for the entire building life cycle. A duty-holder is defined as a key role (whether fulfilled by an individual or organisation) that is assigned specific responsibilities under the regulations at a particular phase of the building life cycle. Thus, a digitally held golden thread of information aims to ensure that the original design intent and any subsequent changes to the building are captured, preserved and used to support safety improvements. The new regulations will include guidance and standards setting out what digital requirements the golden thread of information would have to meet, including specifications regarding the sharing and access of information. This aims to contribute to information being more easily kept up to date, maintained, accessed and used to ensure delivery of safer buildings (Government response – MHCLG 2020).

On the other hand, the interviews revealed that those involved in project delivery are confused about the new duty holder descriptions, and so, the corresponding responsibilities regarding safety information, because they view them in comparison with The Construction Design and Management (CDM) Regulations 2015 that are currently in force. Thus, the contractor did not think that their role would significantly change:

> "As a Principal Contractor under CDM Regs we supply a complete package of information so what is different? …we always make sure that the works have the necessary approvals before we start."
> "We pass all this information to the client via the CDM Regs, so shouldn't a golden thread for a building already be in place?... I can't really see us needing to buy any new technology to deal with the change."

The project architect believed that greater clarity needed to be provided around the responsibilities of the new roles under the proposed system of duty holders:

> "It may not be that easy to transpose CDM Regulations concepts onto a new ongoing building responsibility …I am not sure that I actually know what that means."
> "[At Grenfell] the individual parts of the cladding system might have been compliant with fire regulations but as a whole the system failed so who would be to blame under the new system? This is a grey area when it comes to identification of blame and litigation."

The litigation solicitor had similar concerns as to how the new duty holder framework would mesh with the CDM Regulations and how it would be interpreted and enforced:

> "The safety case1(footnote - definition) will include both "construction" and "housing management" elements. The proposed approach based on the CDM Regulations does not fit well with the housing management perspective, so further thought will be needed with respect to this."

In a similar vein, the findings suggest that the way in which project delivery actors understand and perceive the new golden thread requirement is also based on the existing practices shaped by the Regulation 38 of the current Building Regulations, which provides guidance on the handover of fire safety information to the responsible person before the occupation of the building. In the context of fire safety, Regulation 38 is often discussed and maybe agreed on during the design process, but then not complied with in practice as the design team may not understand how important it is to provide the correct 'as built' fire safety information to the owner (i.e. responsible person). Based on previous experiences under Regulation 38, the managing director of the company of chartered surveyors was sceptical about the ability to produce accurate as-built drawings and other information in a digital format for the golden thread:

> "Clients rarely provide us with as built construction drawings but when they do they are never correct!"
> "Digital records? There are not many clients that can open a CAD drawing, they also request PDF documents."

The approved inspector opined that building control could be the key to making sure that Regulation 38 is complied with; thus, facilitating the golden thread:

> "At the moment everybody seems to pay lip service to Regulation 38 and there is no accountability for how the information is passed over…Regulation 38 must be tightened up and building control officers may have to take a more prominent role in the process to ensure that the information is passed onto the responsible person for the subject premises."
> "How can the Golden thread work if Regulation 38 is not enforced?"

However, the contractor was unfamiliar with Regulation 38, and was sceptical that accurate as-built drawings could be supplied as part of the handover documentation to create an accurate golden thread of safety information:

> "I don't know what Regulation 38 is, but part of our handover process is to pass the initial drawings, as built drawings and fire alarm testing certificates to the client."
> "Is it feasible to have accurate as-built's? It is a dream, it would be nice, but it will definitely take a mentality change…"

Actors involved in building operations are directly concerned with the occupier's safety and currently the 'responsible person' designated under Regulation 38 has the responsibility of ensuring the production and communication of adequate Fire Risk Assessments (FRA).

Arguably, the new requirement for a golden thread of information will be the basis to produce FRAs more adequately with all the necessary information available accurately in a digital format. However, the interviews revealed that different actors who might be tasked with producing FRAs in the industry are taking different fire safety regulations as their basis and also pay little attention to the communication of FRAs with residents; which raises questions about the difference that a digital golden thread of information could make for improved FRAs and emergency action. For example, the residents' fire consultant stated that:

> "The powers ~~that~~ be aren't providing a clear message to the residents of high-rise buildings, better guidelines need to be provided to people about when they should stay put and when that should be changed to simultaneous evacuation."
>
> "Professionals and the Fire Rescue Services are, maybe, carrying out Fire Risk Assessments on the wrong basis, in the original code of practice issued in the sixties [BSI Code of Practice 3] it is understood that residents would want to leave the building if there was a fire and stated that protected fire routes should be provided as an alternative …as fire risk assessors we should be advising clients to install fire alarms and waking watch systems if needs be."

The expert witness echoed the resident's fire consultant's views:

> "I send a completed FRA report to a client attached to a covering email, does that ever get passed onto the residents? If the report makes recommendations to clear blocked communal stairs does the work get undertaken? It may not do…"
>
> "10-15 years ago we established a stupid culture where everybody thought they could attend a half day training session and become a fire risk assessor."

However, the fire engineer, who followed a different guide, the National Fire Chiefs Council's (NFCC) guide (2018), provided a different interpretation of upon what guidance FRAs must build:

> "The evacuation of residents in the event of a fire is complex and if a simultaneous evacuation policy is carried out the residents may inadvertently obstruct the fire rescue

> services, or they may hurt themselves, be crushed, during the evacuation… In my view, staying put is the safest way forward for the residents”

There is no indication that the implementation of a digital golden thread of information of fire safety would solve this challenge of meaningful communication through the prescription of new roles and responsibilities, handover procedures and digital formatting requirements.

Theme two: Fitness for purpose

In the mid-1980’s the English building regulations changed from a prescriptive based system to a performance-based one which lists broad standards and outcomes that new buildings must achieve. This was done to encourage the implementation of innovative design solutions though it can also create uncertainly with respect to compliance.

There are several methods for an external wall cladding system to achieve building regulation compliance. One method allows materials that don’t conform to the limited combustibility criteria to be used in an external cladding system provided that compliant performance can be demonstrated by carrying out the full-scale British Standard 8414 (BS 8414) test which is carried out in a specialist laboratory. If it complies with the requirements set out in BR 135 (BRE Global 2020) then it is deemed to comply with Approved Document B.

The BS8414 is considered to be cost-prohibitive which resulted in the use of the desk-top study method of compliance where building control officers would accept proposed cladding systems that vary from those tested to BS8414 if they had been assessed as compliant with the criteria set out in BR135 by a ‘suitably qualified person’.

The Hackitt Review (2018) was extremely critical of the use of desktop studies and recommended that they be significantly restricted and be carried out only by competent people which was ratified by the government after industry wide consultation. However, the restrictions have been received in different ways by various actors within the industry which has led to differing views being offered as to how the industry should proceed with respect to the restrictions. The extreme option has been to only specify non-combustible materials that will comply with the building regulations and don't require any further laboratory testing. The senior architectural project manager, for example, warned that sustainable design innovation may be stifled as a consequence of these changes:

> *"There is a new emphasis on system testing and rather than carry out the test some architects are refusing to specify combustible materials anywhere on any building, it is stifling innovation in building design …how can zero carbon be achieved if designers won't or can't use sustainable materials such as engineered timber or cross laminated? The UK could fall behind the rest of the world in terms of sustainable design."*

This view was confirmed by the Approved Inspector who advised that the use of non - combustible materials may cause unintended consequences in the future

> *"Already we are seeing design innovation being stifled as developers only want to use non-combustible materials, for example we are seeing the use of stainless-steel cavity trays which though they are non-combustible they may cause problems with movement to surrounding brickwork in a few years' time?*

The residents' fire consultant agreed that desktop studies should be restricted but took a different view on the validity of the BS8414 test and questioned whether it replicated real-world on-site conditions

> *"The BS8414 test is undertaken in an idealised environment, it is not a realistic test. The test panels are normally in perfect condition which isn't how they would be installed on site".*
>
> *"Ultimately the residents are the one[s] living in the building, they have to be reassured about the cladding and know that they are safe…whatever the test results say the thing that matters is how it is installed onsite, the residents need evidence that cavity barriers are installed correctly".*

The fire engineer held a robust view of the BS8414 test, believing it to be fit for purpose but thought it a mistake to restrict the use of desktop studies as they provided a pragmatic way of assessing the fire performance of combustible materials.

> "BS 8414 is one of the best fire tests in the world, none of them are perfect but I cannot recall one major fire that has occurred at a building where the materials passed the BS8414 fire performance test"
> "I think the government will have to rethink desktop studies…it is impractical to apply a BS 8414 test to every external cladding system, there is only one test centre in the UK so how could they cope?!".

The responses illustrated that no universal view is held about the restrictions of desktop studies for BS8414 combustibility test, with each actor not being able to look beyond their own field of expertise and have interpreted the change in regulations to suit their own practices. Hence, compliance, rather than excellence, seems to be the main consideration in terms of how different actors' safety regulations.

Theme three: Perceptions of Risk

In the wake of the Grenfell fire the UK government issued a ban on the use of combustible materials to the exterior of new buildings over 18 metres in height. It also published a series of fire safety advice notes detailing what owners of high-risk residential buildings should do to ensure the building is safe for residents as required by the previously published Regulatory Reform (Fire Safety) Order 2005 (MHCLG 2020a). Until these conditions are met, the flats within these buildings have been valued by lenders at £nil, which has made thousands of high-rise flats unsaleable causing frustration for both landlords and leaseholders. This has occurred because ,in many cases, the building owners did not hold, or could not access, the required technical details about the materials used in the construction of their buildings; hence, they could not provide the necessary absolute assurances that there is no combustible material contained within external wall system (Phillips 2021).

To address this problem, a new safety certification process has been devised by the Royal Institution of Chartered Surveyors, known as External Wall Systems 1 (EWS1) to provide comfort to owners and mortgage lenders by delegating the assessment of fire safety risk to a competent chartered construction professional. The role of the EWS1 assessor is to assess the fire safety risk of a building's external wall system and provide a certificate stating whether the building would require remedial works based on the materials and systems installed. The idea behind this process was that this certificate would help residents feel safe and mortgage funders resume lending for HRRBs. (Phillips & Martin 2021)

However, the interviews revealed that even the advent of this certification process has not achieved the desired result. The Client-side Senior Manager reported that there are still significant issues with the assessment process.

"The information provided by the Fire Engineers was easy to understand but due to issues around professional indemnity we found that they would not make direct recommendations with respect to the materials that could be used in recladding works… The underwriters did not understand the fire mitigation issues"

This was confirmed by the Project Director of the Chartered Surveying Practice who stated that the stance of professional indemnity insurers has changed the way they need to inspect HRRB's and how they compile on-site records:

"Unless we know exactly the type of external cladding that has been used or we can undertake intrusive investigations then we are unable to sign off an EWS1 form…not all clients hold the necessary records nor fund the cost of an intrusive inspection which can cost between £25,000-£75,000 depending on the size of the subject building"

Thus, the sale of high-rise flats remains extremely difficult. The nascent EWS1 process stalled as professional indemnity insurers focus on regulatory risk i.e ~~the~~ risk that the implementation of new regulations will cause them monetary losses, and this has meant that insurers will not provide full insurance cover to professionals for fear that it may shift liability for a building's future safety onto the chartered professional.

Consequently, the insurers' stance has also meant that, in some cases, professional surveyors and engineers have started to consider legal and reputational risk over fire safety risk and are refusing to sign off EWS1 forms even when there is only a very minimal amount of combustible material to be found on a HRRB. The Project Director described why this issue has occurred.

"If we inspect a HRRB and find a small amount of timber cladding on the external elevations then we will state that the property is a fire safety risk…how can we take any other course of action if our insurers won't provide their standard cover?"

The problem was exacerbated in January 2020 when the Government's expert panel removed the 18m height threshold for a HRRB by advising that owners of all multi-occupied residential premises with cladding or without cladding and *of any height* must consider the fire safety risks presented by external wall systems and fire doors. (MHCLG 2020c). The effect of this was to increase the number of EWS1 inspections requested by mortgage lenders and as the Project Director explained this meant that the EWS inspection was being undertaken to properties that would not usually be considered to be a fire safety risk.

"We are being asked to undertake EWS1 inspections on low rise blocks of flats constructed of cavity brickwork which are extremely low risk in terms of spread of flame but how can we advise that they are not a fire safety risk if we cant confirm the exact material that has been used for insulating the cavity?"

Overall the EWS1 notice has demonstrated that amending regulations and legislation does not necessarily produce the desired outcome because of the lack of shared belief and prioritisation of fire safety risk amongst the various actors.

DISCUSSION:

The examination of a range of professionals' views on the recent changes to building regulations for high-risk buildings in the UK, exposed some important aspects of the organisational culture that drives the safety-related behaviour in high-risk buildings' life cycle. These aspects are discussed through the lens of the HRO literature presented earlier. The first part focuses on the identified cultural aspects, to develop insights into how the safety of high-risk buildings should be approached as complex systems, through a life cycle perspective. The second part discusses the role the building regulations could play to support this.

Organisational culture in high-risk buildings' life cycle

The three themes identified in the findings represent three, important aspects of the organisational culture that drives the safety behaviour in high-risk buildings' life cycle. Theme 1 (perceptions around safety information) highlights that various actors involved in the building life cycle are mainly concerned with their formal information-related roles, responsibilities and information handover, rather than the usefulness or purpose of that information for engagement and meaningful communication with others to assure safety. Arguably, this focus on formal roles, responsibilities and information handover has eventually led to superficial practices, for example, paying lip service to Regulation 38, the disbelief in the accuracy of as-built drawings, and the failure to communicate with residents about fire risk assessments. In turn, these superficial practices further reinforce the focus on formal roles, responsibilities, and document handover, resulting in a lack of consideration of 'safety' as a system-wide phenomenon, when the interviewees talk about a digital golden thread of information as part of the new regulations.

Moreover, by exposing the varying interpretations of the changes to BS8414, Theme 2 (fitness for purpose) highlights that safety regulations are mainly interpreted from a regulatory compliance perspective rather than with a focus on safety excellence. This means that the safety regulations are seen from the perspective of one's own specialist practices and the issues the regulations raise for those specific practices. For example, while the architect emphasises the impact of the ban of desktop studies on design innovation, the residents' fire consultant explains that even the full-scale lab-based tests would not give enough confidence to residents. Thus, it can be argued that, in this situation, the different perceptions of thefitness for purpose of regulations/rules determine the individual perceptions of what matters most about those regulation/rules, and so, the 'acceptable' ways of achieving compliance. This resonates with Hu et al.'s (2020) concept of 'surface compliance' which refers to behaviours that focus on 'demonstrating' compliance, as opposed to 'deep compliance' where practitioners invest discretional effort to support overall safety in the organisation. This is an important distinction to be made, because the type of compliance may reflect the different intentions and strategies that underpin safety behaviour, and their associated safety outcomes (Hu et al. 2020). Hence, arguably, this cultural aspect underpins the behaviour of 'gaming the system' which is highlighted by Hackitt (2018) as one of the important problems in managing safety of high-risk buildings.

Finally, Theme 3 (perceptions of risk) highlights that perceptions of risk, which strongly influence safety-related behaviour, do not exclusively depend on safety risks. There are strong influences of reputational and professional risks that affect safety-related behaviour, even when the consequences of such behaviour lead to significant disruption in practice as in the case of EWS1 certificates. This means that practitioners try to optimise their behaviour through a consideration of their risks, other than the safety risks of the building (i.e. reputational, professional risks) when interpreting situations and making decisions about building safety. The actors in the construction industry typically have adversarial relationships that lead to a 'blame culture', whereby they seek to minimise their level of exposure to poor performance instead of working together to improve the system performance (Baiden et al. 2006).

Overall, it can be argued that these three aspects of the organisational culture in high-risk building's life cycle are in strong contrast with the cultural underpinnings and processes of collective mindfulness advocated by HRO literature (Weick 1987; Weick et al. 1999; Weick & Sutcliffe 2007; Schulman 2020). The focus on formal communication requirements, surface compliance and non-safety risks suggests that there are not reliable premises for making sense of, and decisions about, the developing building safety hazards (Weick 1987). Rather, the premises for interpretation and decision-making shift away from safety due to a major consideration of risks other than safety risks (Theme 3), and become flawed due to the lack of both meaningful interactive communication (Theme 1) and a commitment to safety excellence (Theme 2). In more practical terms, the studied organisation operates upon 'inward-looking' and 'self-concerned' versions of the constructs of risk, danger and safety (Pidgeon and O'Leary 2000), which makes it impossible to develop precursor strategies to catch and contain safety hazards early, and discourages the prioritisation of safety over other organisational goals such as efficiency, speed, cost etc. (Schulman 2020). In this setting, it is very difficult to avoid an attitude of scepticism towards safety where the risk perceived involves risks other than safety risks and the focus is on formal information handovers and surface compliance (Schulman 2020).

It can also be argued that the current organisational culture is not supportive of the five processes that enact collective mindfulness (Weick et al. 1999; Weick & Sutcliffe 2007). 'Pre-occupation with failure', 'reluctance to simplify interpretations', and 'sensitivity to operations' emphasise the importance of informal communications and engagement, continuous learning from mistakes and near misses, commitment to deep compliance, and the prioritisation of safety risks above any other organisational values, which are not supported by the current set of practices. Similarly, 'commitment to resilience' requires anticipation and a collective response to developing hazards, which the current organisation of high-risk building life cycle seems incapable of. Furthermore, 'deference to expertise' seems to be overshadowed by the issues of surface compliance and non-safety risk considerations. Ultimately, it comes as no surprise that operations in the life cycle of high-risk buildings are against those advocated by HRO literature.

On the other hand, the issues discussed in this section can be considered as a direction for improvement, and an answer to the question of how safety of high-risk buildings could be approached holistically as complex systems. To address the safety of high-risk buildings holistically, as complex systems, a change is required in the attitudes and perceptions identified in this research, so that they become more supportive of collective mindfulness. Thus, by revealing the disparity between the identified attitudes and perceptions and the HRO literature, this research establishes a basis for future debate on the way forward for the holistic management of safety in high-risk buildings as complex systems.

Building regulations and managing safety as complex systems

The studied regulatory changes have the ambition of enabling an holistic, life cycle approach to the management of high-risk residential buildings as complex systems. However, the findings suggest that they fall short of enabling the desired change in practice due to the persistence of the cultural aspects discussed in the previous section. However, they do provide some important insights into the role that the building regulations could play in establishing the management of safety holistically, as complex systems, for high-risk buildings.

Theme 1 (perceptions of safety information) exposes that the interviewees believe a digital golden thread of safety information to be comparable with their existing formal information roles, responsibilities and handover practices, instead of seeing it as a novel and improved process for better communication. This means that this new concept is assimilated under the existing formal and distant culture of communication, thus challenging the idea that having a digital thread of safety information would, in itself, ensure the delivery of safe buildings (Government response 2020). This research argues that the current academic and practical interest in digital traceability of building information to improve building safety, (e.g. Watson et al. 2019; Li et al. 2019; NBS 2020) will not achieve a change in practice unless the human aspects of communication are properly understood and addressed.

Moreover, the focus on surface compliance (Theme 2) raises questions about the applicability and added value of outcomes-based regulations and automated digital regulations in managing the safety of high-risk buildings. Outcomes-based regulations describe the required performance outcomes of the regulated entity, as opposed to prescriptive regulations which prescribe the technical and procedural requirements that must be followed (Barua et al. 2016). Although outcomes-based regulations can be preferable to support flexibility and innovation for high-risk building projects which present unique technical challenges, under a dominating ‘surface compliance’ culture, outcomes-based regulations might also undermine safety, and even drive opportunistic behaviour (Hackitt 2018). For this reason, it can be argued that it is not only the competence levels that must be addressed to gain the benefits of outcomes-based regulation (REF) but also the organisational culture must shift from 'surface compliance' towards 'deep compliance'. Similarly, it can be argued that while the automation of regulatory checks through digital technologies (D-COM 2020) can bring a more uniform use of regulations by eliminating the individual interpretations of the regulations, it will not shift the cultural aspect of 'surface compliance' to 'deep compliance'. Hence, automated digital regulatory checks must be used cautiously in managing the safety of high-risk buildings, while a culture of surface compliance exists.

Finally, the various perceptions of risk (Theme 3) that affect safety-related behaviour must be understood and considered as part of any regulatory reform. Meacham and van Straalen's (2018) work, which perceives a building regulatory system as a complex socio-technical system, provides some important insights into where these different perceptions of risk might stem from, and how their roots can be found in the wider institutional settings such as the form of law, credibility of regulatory bodies etc. in a specific country.

CONCLUSIONS

The management of safety of high-risk buildings as complex systems requires a holistic approach that can be based upon the insights from the HRO literature. It might be argued that not all high-risk buildings behave as pure complex systems, as arguably several organisational aspects of many buildings classified as 'high-risk' could be reliably predicted. However, as emphasised by Weick et al. (1999), there are several continuities between complex and not so complex organisations in terms of the development and consequences of safety failures, which suggests the applicability of the findings of this research to the broader set of high-risk buildings. Using HRO literature as a lens, this research examined the perceptions of various built environment professionals in the UK regarding the ongoing reform of the building regulatory regime for high-risk residential buildings. The empirical inquiry is limited to a specific country and the data collected is limited to ten semi-structured interviews. However, the insights developed about the relationship between the organisational culture of the building life cycle, and the management of safety and building regulations are applicable to other empirical settings.

It can be concluded that management and regulation of safety in high-risk buildings requires a deep appreciation and engagement with the organisational culture of the building life cycle. If understood well, and supported to transform into a culture of reliability (Weick 1987), this can assure safety by influencing the safety-related behaviour as presented in the first part of the discussion. Furthermore, as argued by Schulman (2020), and shown in the second part of the discussion, developing an understanding of such cultural aspects is fundamental to making the right regulatory decisions, no matter whether the purpose of those decisions is to change the culture or to support it through structural arrangements. This research demonstrated that the studied regulatory reform falls short of effecting change in the culture, although one of its starting points was to enable that change as stated in Hackitt (2018). Ultimately, more research is needed on the organisational culture of building life cycle to reliably prevent catastrophic safety failures through the management and regulation of safety of high-risk buildings in practice. The three cultural aspects cited, and their implications for building regulations as identified in this research, provide a starting point for future academic contributions.

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