Exterior Refurbishment and Fire Safety Strategies for High-Rise Council Estates in the UK

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Abstract: This research investigates the current exterior refurbishment strategies for high- rise council estates with the aim to enhance fire regulations and reduce risk of fire in buildings. This research outlines the main causes of the catastrophic Grenfell Tower fire and the current Building Regulations that were enforced during the time of its exterior refurbishment (i.e. replacement of fabric/cladding). Potential recommendations/enhancements made subsequent to the Grenfell Tower fire, proposed by the relevant institutions and its professionals, are analysed. A case study based in the borough of Westminster is then analysed in order to assess its proposed exterior refurbishment strategy in relation to compliance with the building regulations and safety requirements. The results reveal that although the refurbishment strategies have improved, there are some defects in the enforcement of the regulatory systems that should be addressed.

Keywords: Grenfell Tower; Fire Safety; Refurbishment; Building regulations.

1. Introduction

This work was developed with a view to the topic "Professional Delivery of Sustainability". While sustainable strategies are being implemented and enforced to reduce the collective carbon footprint, it is also important to ensure that they are in fact safe and do not pose a risk to the safety of a building's occupants, particularly in high-rise residential buildings. An example of unsafe refurbishment is the catastrophic fire that occurred at Grenfell Tower in London in 2017, claiming the lives of many innocent people.

The original construction of Grenfell Tower [1,2] was commissioned by the Kensington Chelsea borough council in the 1970s. According to [3], the tower design was commissioned in 1963 by the firm "Clifford Wearden & and Associations". The planning permission was then granted in 1970 and construction of the tower started in 1972 and was completed in 1974 by the main contractors "A E Symes" [4]. The tower comprised of 24 storeys which had anticipated to contain 124 residents [3]. The primary structure was comprised of mainly in-situ concrete columns and slabs and precast concrete beams. The exterior façade was comprised of insulated precast concrete, which improved the thermal performance of the building.

The refurbishment of Grenfell Tower had started in 2014 and was completed in 2016 [5]. In 2012, the TMO (The Kensington and Chelsea Tenant Management Organisation) had undertaken consultations for the refurbishment of Grenfell Tower, which had included improvements to its façade and mechanical and electrical enhancements [6]. A planning application was submitted to propose these alterations to the local authority, at a total cost of £9.7million. The architectural firm "Studio E Architects" was appointed and the main contractor "Rydon Group" was responsible for such works [7]. In terms of the specific proposed alterations, according to [8], the exterior façade included: a cladding system which covered the entire surface of the building, new windows replaced old existing windows and the implementation of a communal heating system.

The events of the Grenfell Tower fire were published widely at the time and for many weeks after. It was a catastrophic event which will always be remembered in the history of the UK. The incident happened on the 14th of June 2017. The fire had first started on the fourth floor of the building due to a faulty Hotpoint fridge freezer. The fire had rapidly spread from the east side of the building to the north until it had surrounded the whole building and, unfortunately, 72 people lost their lives due to the incident [9], The fire spread quickly, specifically through the cladding system [10]. When the flame had escaped the building, it started to burn the aluminium panelling, and then the fire entered through the gaps between the panelling and the insulation. This was effectively the reason for the alarming rate of spread upwards and was also one of the reasons the fire could not be controlled by the firefighters. According to [11], another cause of how the fire had rapidly spread throughout the building was from the 10 columns located around the building. These columns were covered with the same cladding which was one of the building's design features. As the same type of combustible cladding and flammable insulation was used, the fire had quickly spread through the air gap, creating a chimney-like effect. Looking at the materials used for the cladding systems, the panels were combined with poly aluminium sheets and polyethylene, which acted as a filler [10]. As this material melts at low temperatures, it caught fire, which also played a part in why and how the fire spread very quickly.

When it comes to the construction of a project, it is vital that the proposed design complies with the relevant building regulations; "Part B: Fire Safety" being one of the most important ones. "B4 -1" in "schedule 1" of the Building Regulations 2010, deals with the compliance with fire safety in terms of external fire spread [12]. According to the regulations, the external wall/façade of a building must be able to prevent the spread of fire over the walls, meaning that, in the case of Grenfell Tower, it failed to comply with B4-1 [13,14]. According to Dezeen [13], the air gaps between the insulation and the cladding panels led to the fire to spreading throughout the entire building. It is stated that the cavity barriers with strips were poorly installed and included gaps, making them ineffective in the event of a fire. Correct installation of the cavity barriers could significantly reduce the risk of fire spreading at such a rapid rate. The Approved Document B (fire safety) states that for a fire separating element (cavity barrier strips) to work, any openings in the building, such as joints, services, etc, must be sealed.

Weaver [15] states that the building regulations at the time were not fit for purpose as they had allowed for cost-cutting materials, as well as allowed contractors to be excessively budgetary, which had led to the cladding used on Grenfell to become flammable. To this end, this paper intends to investigate the current exterior refurbishment strategies for high-rise council estates that comply with the UK fire safety regulations.

2. Research Methods

The relevant refurbishment systems/strategies used for Grenfell Tower and the causes of the fire have been investigated. The current Building Regulations at the time have been assessed to identify areas for improvement. A high-rise council estate was selected and analysed as a case study to assess and understand design, decision making and control procedure in relation to its exterior refurbishment strategies. A detailed analysis of the proposed materials and strategies was conducted to ensure that all selections comply with the Building Regulations. A visit to the building site was made and images were taken, with a focus on the cladding systems/exterior façade, and CAD detailed drawings were produced. A comparison with the Grenfell Tower in terms of the components/materials was then made to assess the appropriateness and compliance of the proposed cladding strategies.

3. The outcomes

Following the Grenfell Tower incident, a series of inquiries into the event in relation to the cause of the fire were made. Some of these inquiries included the original state of the building and modifications to the exterior façade of the building, and justification to whether the refurbishment of the exterior facade was compliant with relevant fire safety and building regulations [16]. One of the main outcomes of the inquiries was related to recommendations for enhancements and modifications to the regulations and guidelines as well as to the use of combustible materials [17].

Accordingly, the UK's Ministry of Housing, Communities & Local Government (MHCLG) allocated £600 million towards the replacement of the combustible cladding systems on high-residential buildings for both the social and private sectors, as well as provided advice on the range of cladding substitutes which met the fire safety/rating provisions. For new buildings, the MHCLG has banned the use of combustible materials used on any new high-rise residential buildings [17]. Additionally, the government has emphasised the importance of the testing and classification of cladding systems and further recommendations on how testing can be improved and conducted through the "Construction Product Standards Committee"[17]. This would allow for the identification of combustible materials before they are used in buildings, resulting in increased fire safety.

"Building a Safer Future" suggests that the regulatory system put in place by Building Control and local authorities is not fit for purpose. Ignorance and/or lack of knowledge, misunderstanding and priority of time and cost to safety have been highlighted as the key issues. regulatory oversight and enforcement tools should be added to the above issues [18]. This implies that when relevant building regulations are not implemented or considered in a project, the penalties are so small that they are ineffective and hardly consequential for the rule-breaker(s). Some recommendations have been made to address these issues: more severe enforcement powers which would lead to the consideration of building regulations when constructing a project; a simplified regulatory approach to building standards which would make it easier for people to implement and understand in their projects. In terms of proposed materials, there should be a reduction in desktop studies and more physical testing of materials/systems to ensure that they are safe to use [18].

A new regulatory framework for multi-occupancy Higher risk residential buildings (HRRBs) has been developed specifically for buildings of 10 or more storeys. Figure 1(a) [19] indicates the map of the previous regulatory system in place and Figure 1(b) [20] indicates the new proposed map. The old map was highly complex and had "overlapping" sets of legislations which had made it harder to understand and follow. However, the new HRRBs map has been refined and is easier to follow, ensuring its use is effective and beneficial [18]. The main purpose of the maps is to give assistance and guidelines for constructing and maintaining high-rise residential buildings. This is represented in the form of a flow chart which, in each section, includes legislations/building regulations that must be abided by. The UK Government is strongly considering restricting or even banning desktop studies-especially on cladding systems [21]. The Government is also working on improvements to Building Regulations fire safety guidance.

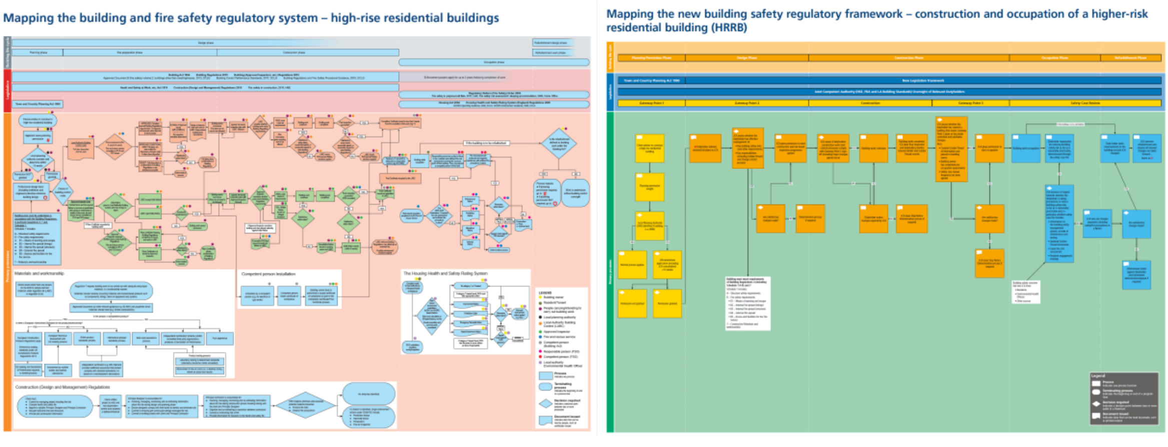

Figure 1. Mapping the building and fire safety regulatory system- a: old framework (left); b: new framework (right) [19,20].

4. Case study

After the Grenfell Tower incident, the government requested tests to be carried out on buildings that were more than 18 meters high and had an exterior cladding system. The outcomes of the tests revealed there were many buildings that needed urgent attention. According to Torpey [22], there were 254 unnamed buildings and 124 residential buildings which failed their cladding tests. The amended Building Regulations 2018 (SI 2018/1230) put a ban on the use of external combustible materials for high-rise residential buildings which are above 18 meters [23].

The case study selected for the purpose of this research is one of the high-rise residential blocks, referred to as "Polesworth House", located in Westminster, London (Figure 2), that had failed the cladding tests [22]. The building is assessed in terms of its current state (external facade) and the proposed new external refurbishment strategy. In terms of Building Regulations, the local authority (the City of Westminster) is responsible for ensuring that its building cladding meets the requirements of the Housing Act [24]. There are multiple steps that the local authority has taken to ensure the safety of Polesworth House.

Figure 2. "Polesworth house"; Left: 2012 [25]; Right: 2020.

The primary structure of the building is composed of a concrete frame with its current architectural style, known as Modernism. The tower has a total of 21 floors above the ground and a height span of 61 meters [26]. The tower was constructed by "Wates Construction" Contactors and was completed in 1962. The existing cladding system is comprised of Rainscreen (Face fixed 4mm ACM), pressed metal work and column casing [27]. As the cladding was confirmed to be combustible [28], the local council developed a detailed plan for the safe removal of its cladding system with an estimated removal by November 2017.

To analyse the building and the current stage of its cladding system replacement, a visit to the site was made and a photographic survey was carried out. These images indicate that the combustible cladding system was taken down, exposing the original building façade (Figure 3).

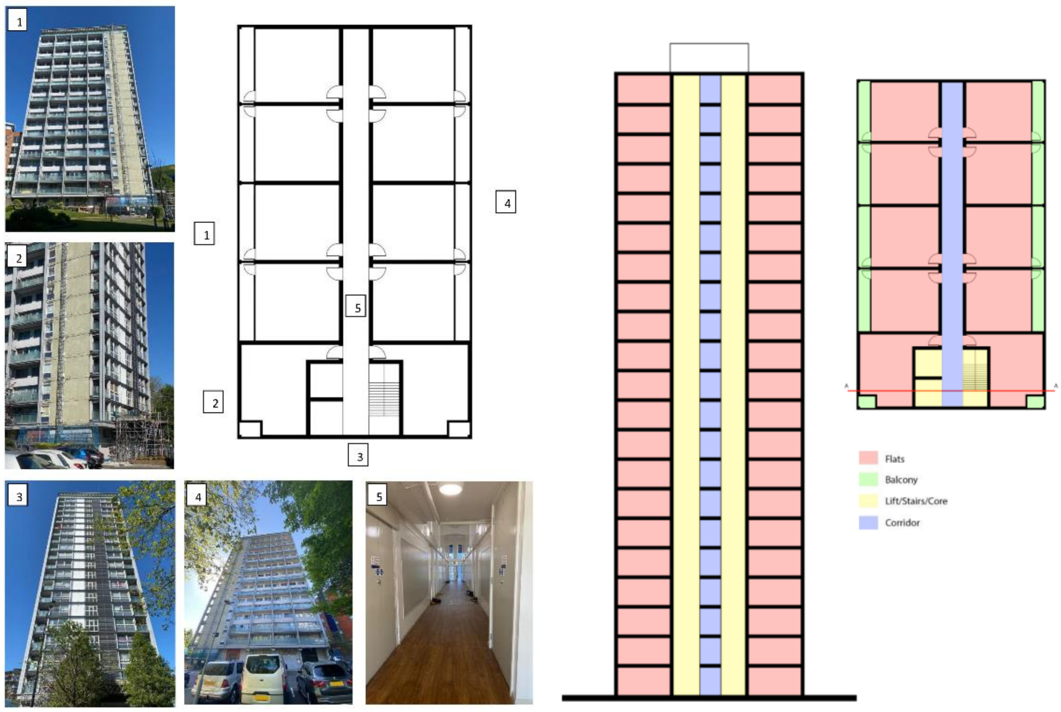

Figure 3. The case study building "Polesworth house"; an approximate section and plan.

In terms of the new exterior refurbishment strategy (Figure 4), the council taken a different approach and is proposing to install a refurbishment system referred to as the "external wall insulation" (EWI) rendering system [29,30]. Comparing this external wall insulation cladding system to the ACM cladding system, one of the main reasons for this consideration was the fact that the main system in recognised as an A1 system, meaning that it is completely non-combustible. According to The Green Age [31], EWI is not recognised as a rainscreen cladding nor a cladding system in general, which means that it would not be subject to any ongoing testing criteria. This results in a rapid installation process. There are other reasons as to why EWI is preferred over ACM. Table 1 summarises the advantages and disadvantages of the systems.

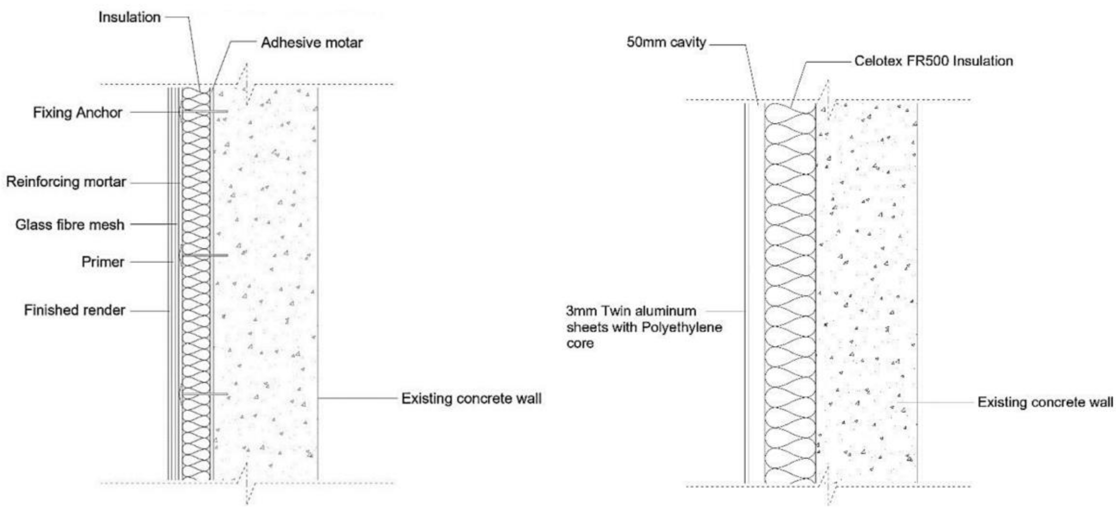

Figure 4. On the left is a wall detail of the proposed exterior refurbishment strategy (EWI) for "Polesworth house", compared to a wall detail of the previous cladding strategy.

Table 1. Comparison of EWI & ACM

Advantages of EWI over ACM	Disadvantages of EWI over ACM
• EWI system is constructed of non-combustible materials. • EWI system does not include a cavity or air gap, eliminating the changes of fire spreading through the cavity/airgap. • EWI system is a cheaper option when compared to ACM. • The life Expectancy of EWI systems is predicted to be for 60 years. • EWI has improved thermal comfort for residents. • This strategy could be adopted by other high-rise residential buildings, which would reduce the risks of a fire occurring as the system would be rapidly installed without delay. • Enhanced fire safety standard	• Rendering of EWI systems may not be pleasant when compared to ACM systems as they look more modern. • The EWI system can only be installed during specific temperatures as it involves some wet- works. This drastically limits the flexibility of its construction operations, as its schedule is dependent on the weather conditions of the site location. • Installation of EWI systems may be longer as delays may occur from the cause of weather conditions.

When it comes to the refurbishment of other high-rise domestic buildings, EWI (exterior wall insulation) systems may not be the best option as, in some cases, they are classified as 'non-aesthetically pleasing'; this is subjective but entirely depends on the client. In this case, there are multiple manufacturers who produce ACM (aluminium composite material) cladding systems that are classified as non-flammable. An example of this is referred to as "Alucobond A2", which, according to RCM building boards & facades [32], is an ACM cladding system that can be used for buildings over 18m. The system consists of two aluminium cover sheets filled with a mineral polymer core, which has high levels of rigidity and impact resistance, which therefore means it has superior durability overall in comparison to other available products. Most importantly, it is non-flammable and abides by the current fire rating standards "EN 13501-1 class A2-s1,d0". Figure 5 illustrates a typical assembly of how the system is put together [32].

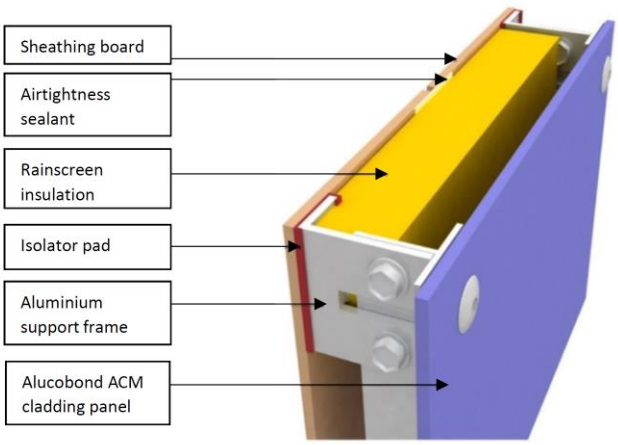

Figure 5. A typical assembly of the "Alucobond" ACM system [32].

According to Tristone Solid surfaces [33], the "EN 13501-1 class A2-s1,d0" standard includes classifications of the different ACM systems which also consists of guidance that must be followed.

In terms of the Alucobond ACM cladding system, it is classified as grade A2, which means that no combustible materials were used in its manufacture. In addition to this, the system is also BBA (British Board of Agrément) certified, which, as stated by Metrotile [34], is a certification recognised in the construction industry for high quality products, high quality manufacturers, etc. As the system is built up from non-combustible materials, in an event of a fire, the rate at which the fire spreads is significantly reduced [35]. To guarantee that the cladding proposed by "Alucobond" is non-combustible, multiple fire tests have been conducted. According to Alucobond [36], four BS8414 large scale tests replicated many scenarios that would occur in a fire. This included measuring the speed and distance of the flame in terms of internal and external fire spread, the combustibility of the components in the system and the burning droplets and smoke produced by the flame. The cladding systems included non-combustible panels and non-combustible mineral wool insulation. Apparently, the system had not shown critical rises in temperature or a major development in the flame exceeding the enforced requirements of the BRE (Building Research Establishment). In the case of Fire Retardant ACMs, the fire may start on the ground floor and develop to the first floor and then be delayed, meaning that the cladding system stalls the development of the fire, in turn giving ample time for residents to escape and reach a safe proximity away from the building. This also gives enough time for firefighters to put out the fire and prevent it from developing further.

5. Recommendations

In the case of the Grenfell Tower, the main cause of the fire was the combustible ACM cladding that was used. This had also involved incorrect installations of the system and defective cavity barriers, which had resulted in the rapid spread of the fire around the building. One of the main reasons for the incident was the unclear regulations (which may have been one of the reasons the lack of full compliance with the fire regulations) as well as the enforcement systems. The Grenfell Tower is an example of how the regulatory systems are not fit for purpose.

Accordingly, there are multiple enhancements/recommendations which can be implemented to ensure the fire safety of high-rise residential buildings. First, it includes making sure that manufacturers and contractors abide by up-to-date regulations, and, if possible, exceed those standards to assert a'strive for better' approach in the construction sector. This consists of enforcing stricter penalties such as fines, closure of the company or the removal of its chartership. The existing fines/penalties do not live up to the seriousness of the consequences that can result from incompliance (i.e. the fire at Grenfell Tower taking many lives), and thus it is important to approach this in a stricter way. The second includes making testing of all types of exterior refurbishment strategies mandatory and then this must be approved by the relevant institutions before it can be used in practice. This would include real-life testing and possibly fire simulations to be used, based on the classification of the components used in the specified system. As well as having the full plan building application for submission, the third recommendation could include mandatory inspections at the commencement of a project, carried out by a professional body from the local authority, and at other significant stages of the construction pertaining to the installation of its exterior systems, with fire safety at the core of its inspection. This would comprise of ensuring the system used is non-combustible, the system is secured to the building while adhering to the relevant Building Regulations, and guaranteeing that fire precautions such as cavity barriers and fire stops are implemented correctly based on the regulations and the manufacturers' specifications. This guarantees that contractors who ignore building regulations and standards are not constructing the building for the sole purpose of making a profit, and are consistently supervised during the relevant stages of the construction. Finally, the guidance and enforcement of the maintenance of the exterior façade could be improved as systems could fail over time, which may decrease its duration of fire resistance and durability factors in general, which, as a consequence, can also impair its resistance to fire.

5. Conclusion

The major cause of the fire at Grenfell Tower was the combustible cladding system, which had resulted in the repaid spread of fire, as well as the poor design and the Building Regulations being "not fit for purpose" playing a part in the incident. When it comes to different exterior refurbishment strategies for high-rise residential buildings, there are a limited number of external systems which could be used due to the high risk of a fire occurring. The replacement of the combustible cladding system with EWI (external wall insulation) and Enhanced ACM (Aluminium composite material) would improve the situation. Further on from the horrific incident at Grenfell Tower, the UK Government has taken precautions to prevent the likelihood of similar events occurring again. The issues that caused the fire at Grenfell Tower have been identified and recommendations such as new regulatory systems have been provided. The implementation of such recommendations would guarantee that buildings are built and maintained in accordance with the regulations, improving the safety of residents of high-rise residential buildings.

Author Contributions: Hashemi designed and supervised the project; Fahmi carried out the investigations.

Conflicts of Interest: The authors declare no conflict of interest.

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