APPENDIX A1-3:
CURRENT TRENDS IN RESIDENTIAL BUILDINGS

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A1(3).1 Introduction

A1(3).1.1 Background

In June 2017, the Grenfell Tower fire resulted in the death of 72 residents, many others becoming homeless and a wider impact on the local community. The incident also posed a significant challenge to the operational capabilities of London Fire Brigade. In response to the Grenfell Tower fire, Dame Judith Hackitt conducted an independent review of Building Regulations and fire safety in England where she noted that "…*further research with the construction industry to understand who uses Approved Documents, how they are used and where they are used to influence how they should be developed in the future*…" was needed.

This report provides part of the first stage deliverable in a project that considers the means of escape in residential buildings as part the further research by MHCLG on any future technical changes to Approved Document B (ADB). As part of **Objective A1**, to establish building design principles underpinning evacuation strategies, this task (**Task A1_3**) is being carried out in parallel to identify current trends in residential buildings related to means of escape. The task has engaged with a group of industry professionals to understand future design and building use trends. It has also carried out a review of selected published articles in relevant trade journals, but not an extensive appraisal of the literature.

Separate to this this report, the associated tasks covered by Objective A1 are:

- **Task A1_1:** Review literature on physical design measures which support or influence building evacuation. Examine literature that identifies non-residential / non-UK design measures that might be employed in a UK residential setting, and examine measures employed in mixed-use settings. Identify measures and underlying assumptions in relation to benefits on building evacuation and mitigation of fire conditions, and
- **Task A1_2:** Review regulations and authoritative guidance regarding means of escape in residential buildings, including UK and international resources.

A1(3).1.2 Interviews

Section A1(3).2 of this report digests the responses received during interviews with various industry practitioners as part of a consultation to gather information about current and future trends in high-rise residential living, and the impacts that these might have on evacuation provision. A wide range of trends were considered – from anticipated technical developments to social and demographic changes – over the course of an hour's conversation with each participant (or in some instances more than one participant together). Participants were free to discuss any topics that came to mind, but some steer

was given by the interviewers to make sure certain areas were covered. Those involved had a variety of roles, including architects, developers, local authority housing officers or housing association managers, and the fire and rescue services. Comments have not been attributed to individuals to allow them to speak candidly. The comments should not be taken to necessarily reflect the position of the organisations the individuals work for, and the findings do not necessarily reflect the views of all participants.

As summarised here, there are a number of factors that are influencing the design of high-rise residential buildings (Section A1(3).2.1). Not only is the underlying demographic of the UK constantly changing but there is a shift in the demand for different sectors of the population to live in central city areas. The impact of these demographic changes is discussed in Section A1(3).2.2. In parallel there is a greater focus on providing shared amenity areas in residential buildings. These spaces are seen as being very important because they 'make life better' and are critical to the success of a building. Section A1(3).2.3 further discusses shared amenity areas in more detail. Therefore, not only could the demographic of residents affect the evacuation strategy but also the extent to which shared amenity areas will be available in the building, and what these areas might be. An evacuation strategy that solely relies on 'stay-put' may not be applicable to buildings with extensive amenity areas, and this is elaborated upon in Section A1(3).2.4. As observed in Section A1(3).2.5, whatever the evacuation strategy for a building, it is important that it be communicated with residents effectively.

From a wider perspective there is a lack of confidence affecting the sector with particular concerns with the implementation of 'modern methods of construction' (MMC) – these are discussed in Section A1(3).2.6 and Section A1(3).2.7 respectively. The impact of various financing and tenure models involving residential buildings is discussed in Section A1(3).2.8. Thereafter Section A1(3).2.9 considers the modification of the current building stock and whether broader social changes in work and retail patterns will release existing buildings for residential use. All of the factors listed above influence the selection of fire protection measures (Section A1(3).2.10) including active systems such as sprinklers along with stairs and compartmentation. Finally, the likely changes in the types of heating and power systems installed in high-rise residential buildings to meet climate change targets, and whether these will have fire safety impacts, are considered in Section A1(3).2.11.

It is important to note that the authors of this report do not necessarily agree with the opinions expressed by the interviewees. The statements vary between those that are factual and those that are subjective and therefore carry a level of uncertainty. It has not been the objective of the authors of this report to establish the veracity of any statements through the technical knowledge available in the literature.

A1(3).1.3 Article review

Section A1(3).3 gives a brief review of some selected articles published in academic, trade and the media. In particular the review has sourced material from Inside Housing, a leading trade magazine for housing professionals in the UK, to look for trends within the high-rise residential building sector.

Previously Turkington et al. [1] examined trends and future prospects of high-rise housing across Europe. The authors identified seven ‘megatrends’ that could impact the position of high-rise residential buildings on the housing market, as noted below.

- Technological: People will have less need to live close to where they work, and this may mean flats will be considered too small. One outcome might be that bigger flats might be created by joining them together. Problems with congestion and parking but also the growth in public transport will mean the location of high-rise buildings will become important.

- Economical: The unification of states (across Europe) and an increase in GDP will affect the demand in different regions leading to market polarisation.

- Political: Changes in social welfare and an increasing of market provisions may result in more private investment and less state subsidies. Competition could lead to better quality buildings but may also result in poorer building maintenance.

- Demographics: An increase in the share of the populations that is retired will demand more housing with care, and housing that is manageable and secure. The location and maintenance of high-rise housing may be unsuitable for the elderly. The movement of people may result in tension between residents and immigrants which could result in ghettoization.

- Socio-cultural: Norms and values evolve with an increasing diversity of choices. Household sizes will decrease along with an increase in needs and preferences. This might mean high-rise buildings are seen as outmoded, but on the other hand these buildings will suit individual lifestyles.

- Crime and disorder: High-rise buildings may be subjected to an increase in crime and deviant behaviour although investments safety measures may provide an upgrade in the perceived and actual rates.

- Sustainability: There will be greater concern with the environment. This will impact on the use of sustainable, reusable materials and also energy consumption. Demolishing buildings will be seen as wasteful.

Given the work of Turkington et al. was published back in 2004 it is interesting to consider which of the trends have come to fruition over the last two decades or so and may continue further into the future.

A1(3).2 Detailed interview findings

A1(3).2.1 Building design

Although the discussions did not go into great detail on the planning and design of high-rise residential buildings, specific points were raised. Participants noted several broad changes in the design of residential buildings driven by a range of factors. It was suggested that arranging living space in flats is relatively straightforward, whether that be open plan, compartmentalised etc. In some regions of the UK, local authorities are adopting space standards for affordable social housing projects (for example in Glasgow [2]). Although such standards are being driven by carbon reduction targets, they also have provisions that require, for example, space for a through floor lift, space for an office area and the ability to charge electric vehicles. Similarly, initiatives such as The London Plan [3] is ensuring that there are egress provisions for disabled residents. It was felt that in future the guidance given by the Approved Documents needs to be better integrated rather than treated as individual documents. The knock-on effects of updates to one document are not always reflected in other documents.

There is a trend of making tall buildings which combine various uses (retail, residential, hotel) sometimes with a single staircase extending into the basement or to a concierge / foyer at ground level used as an amenity space (see Section A1(3).2.3). Buildings that are being designed for senior living are now including doctors' surgeries; reading rooms; beauticians along with areas for socialisation. Senior living and also the post-COVID-19 world might result in different building-use patterns both in terms of the time of day and the time of year. As such, this could change the expectations on the number of people in a building, and their locations, throughout a day. It would therefore be useful to better understand actual occupancy rates, to appropriately size escape stairs etc.

It was observed that developers are looking to put as much design responsibility as possible onto architects, rather than separately employing specialist fire engineers. It was suggested that this may affect the ability for the building fire strategy to be followed through from early design to implementation to make sure it stays relevant and will work. Another participant felt that the fire and rescue services are moving more fire safety responsibility onto other parties.

A1(3).2.2 Changing demographic

There is a clear demographic trend in the UK towards an aging population [4], along with elderly people being cared for in their own homes where possible rather than being moved to sheltered accommodation or care provision. Several participants noted that there is a change in the demand for city living, not only by what might be seen as the traditional younger demographic but also with older people such as recent retirees moving from the suburbs into the city so they can be close to social activities such as theatres and restaurants. The lack of land in centre of cities invariably means these people will be living

in high-rise buildings. Most of the demand for high-rise residential buildings is in the major cities across the UK including London, Manchester, Birmingham and Glasgow. High-rise buildings in other towns and cities are often designed to be ‘iconic’ and challenges with environmental conditions (e.g. salt, wind) in coastal areas are likely to limit developments

Depending on the building tenure conditions (see Section A1(3).2.8), residents may choose to live in desirable parts of the building such as the upper floors. Those that are recent retirees may likely be sufficiently capable to self-evacuate using stairs but as they grow older, they may find that their situation changes. This raised the issue of how those people could be managed and whether it is appropriate (or even possible) to move people to different parts of a building (or another building) should the circumstances dictate that as the optimum solution.

The previous points indicate that it is increasingly likely that high-rise buildings will house older residents, including those with impaired mobility and/or cognition. Participants recognised that this presents issues with respect to evacuation and various solutions were discussed including the need for wider doors, more space for manoeuvrability, etc. A broader use of evacuation lifts is anticipated, although it was recognised that without facilitated access and some form of ‘triage’ system, access to and use of such lifts by elderly residents may not be possible. It is probable that a dedicated person on-site will be required to operate and assist evacuation of vulnerable people but this places additional financial burdens to housing providers. A re-think of the guidance governing the use of (non-firefighting) lifts in a fire emergency was urged by at least one participant, to understand and manage the actual risk associated with their use in such circumstances. Concerns were also raised on the reliance on a single fire-fighting lift for taller buildings which might be out of action for some reason.

One participant responsible for social housing provision reported their practice of developing personal emergency evacuation plans (PEEPs) [5] reflecting the needs of individual residents. An example given was of an elderly immobile resident in whose flat a water mist system was installed, providing an alternative to evacuation should a fire occur in the flat. Anticipating such needs at the design stage and building adaptability into the building concept will allow such modifications to be undertaken in a cost-effective manner. However, other participants have found the introduction of PEEPs to be a challenge if there is not a dedicated person in the building to implement them and had concerns about the management of information for the fire and rescue services. There was discussion about the use of emergency information boxes, accessible to the fire and rescue services and containing information about any special evacuation needs of residents. The question was raised whether this information could be made more accessible using a QR code and an online database, although it was recognised that this would pose data security and confidentiality concerns.

A1(3).2.3 Shared amenity areas

All participants saw a clear trend in the use of shared amenity spaces, such as roof terraces, kitchens, dining rooms, common rooms etc. The COVID-19 pandemic has got

some residents to question whether they are content with having no access to an outside space such as a garden, and a small balcony may not provide a sufficient alternative. Whilst spaces such as roof terraces will inevitably be located at higher levels in the building, living spaces higher up in the building tend to be more desirable for accommodation meaning that amenity areas will tend to be on lower levels. At lower levels of a building, the question of evacuation was seen to be less problematic since it is relatively straightforward to evacuate from a first or ground floor space. Some parts of the UK have specific guidance about where such amenity areas are permitted, requiring them to be placed lower in the building. Higher in the building, participants recognised that there was no clear answer about whether evacuation should follow a *stay-put* or a *leave now* approach (see Section A1(3).2.4), or whether there should be a hybrid strategy involving evacuation alarms in shared spaces and *stay-put* in flats. However, some participants were concerned that having a mixture of evacuation strategies in a building (e.g. stay-put in flats, phased in other spaces) was too complex.

It was suggested that there are possible conflicts between amenity areas being ‘their space’ while they are using it versus not ‘their space’ when taking any responsibility. Similarity shared spaces might be ‘taken’ by one resident group at the exclusion of others. It was felt that the number of people within amenity areas may have to be controlled and safe evacuation needs to be ensured if necessary. Shared spaces need to be managed appropriately otherwise they will become unsafe (e.g. poor housekeeping, improper storage) and this is truer if there are no permanent staff to manage them. There could be an argument for protecting shared kitchens and dining areas to a higher fire protection standard than other areas.

A1(3).2.4 Stay-put evacuation strategy

There was general consensus among participants that the *stay-put* strategy widely adopted in high-rise residential buildings is the correct approach, although with some reservations. Human behaviour and the way in which building is operated are critical. The strategy is not well understood by residents and not even by many professionals. The circumstances of when to stay-put and when to evacuate need to be well defined by those responsible for the building, explained to residents when they occupy their flat, and must be reinforced throughout their stay. This explanation should be more than just handing over information on arrival but should be an engagement appropriate to them (see Section A1(3).2.5).

Some participants with responsibility for managing high-rise buildings reported anecdotal evidence that their residents would be reluctant to stay-put in the event of a fire. The policy of a number of fire and rescue services to deploy multiple appliances to reports of fire in high-rise buildings makes it more likely that residents would be aware of – and anxious about – a developing incident. However, this reluctance for residents to stay-put was not universal.

Assurance in the stay-put approach is dependent on being able to have confidence in building elements such as the compartmentalisation and the smoke management system. Stay-put may not be appropriate for legacy building stock and one housing provider uses a

simultaneous evacuation strategy for properties from late 1800s / early 1900s, which are typically six storeys, because the internal fire separation cannot be guaranteed. Experience of the realities of building construction and the desire of residents to customise their properties suggests that without strict controls in place, the fire integrity of such buildings could be compromised. Since the stay-put evacuation strategy requires confidence in robust compartmentalisation, uncertainty about this might undermine this strategy. Some issues around this are further discussed in Section A1(3).2.6.

It was also pointed out that given the stay-put strategy relies on the prevention of fire spread then this also benefits insurance providers. The strategy reduces property loss and claims become complex when several properties are damaged which are insured by different providers.

A1(3).2.5 Resident engagement

Engagement with residents was seen a very important means of ensuring the success of a building's evacuation strategy, whatever that might be. Participants agreed that simply providing information to residents when they moved in was not an effective method of ensuring that they understood, and had confidence in, the evacuation strategy. Residents may not have English as a first language, but even where information is translated to other languages, the conceptual understanding of the evacuation strategy may still be unclear. Therefore, some participants expressed the importance of explaining to residents the strategy and its justification, rather than simply providing information and expecting the residents to interpret and understand it correctly. Ideas such as commissioning residents to produce a bespoke emergency response video, were seen as examples of encouraging residents to take ownership of the strategy and facilitating its wide acceptance within the resident community. Engagement was seen as a long-term commitment to ensure that awareness of safety matters remains relevant through changing circumstances.

A1(3).2.6 Stakeholder confidence

At least one participant noted there is a lack of confidence across many stakeholders post-Grenfell Tower (but it is likely this is also as a result of the balcony fire in Barking and events such as The Cube incident in Bolton, although these incidents were not specifically mentioned). This current climate in the high-rise residential sector has impacted on the willingness of investors to take opportunities with development options perceived as unproven or otherwise risky. Such options might range from buildings with only a single staircase, to a building constructed using methods of construction with insufficient track record to demonstrate appropriately safe operations. Amongst some participants, there was a strong sense that investors are looking to future-proof their investment and attempting to anticipate possible requirements or prohibitions that might be imposed by regulators in the future. However, another participant took a different view, stating that in their experience, developers would not go significantly beyond what was required by regulation and industry good practice. To do so could render a development unprofitable or less profitable, by reducing the size or number of flats available. The divergence in opinion on this matter is likely to be due to the various markets being addressed by the different participants.

There is also a driver from the insurance market who may insist on measures above and beyond what is required by building regulations and the associated guidance, although not all participants agreed this was the case. Similarly, some local authorities are taking a similar view, for example requiring balconies in low-rise building be constructed of non-combustible materials. There was concern expressed that in the longer-term buildings may become difficult to insure, mortgage, sell and/or find people willing to be residents should they not follow the prevailing guidance in ADB (or similar).

There was a perceived mismatch between the objectives of government with respect to climate change and fire safety. For example, restrictions on use of cross-laminated timber (CLT) because of fire safety concerns could lead to future developments being capped at just below 18 m. The appetite for high-rise residential buildings could be reduced if it is not possible to build 'green'. Another factor which could affect the appeal for high-rise residential buildings is the performance and functionality of the proposed Building Safety Regulator. If the system is bureaucratic and overly reliant on input from a small number of experts, this could provide a bottleneck and could stifle demand.

It was felt that the training and education of construction professionals should be greatly enhanced. Historically there has been very little emphasis on fire safety (and specifically compartmentation) within industry. One participant is aware of cases of poor construction practice involving architects, manufacturers, etc. where people were signing off works who were not qualified to do so resulting in projects where things went wrong start to finish.

Fire safety should be seen as a marketing point for high-rise residential buildings, and it was speculated on whether there could be a fire safety accreditation scheme, similar to energy efficiency. Whether such a scheme should be mandatory or voluntary was not clear.

A1(3).2.7 Modern methods of construction

There appeared to be some differing perspectives on what is or is not a 'modern method of construction' (MMC). One participant pointed towards the categories used by the government task force on MMC [6] which provides a set of definitions. This participant noted that some types of MMC e.g. pre-cast concrete elements are often not seen as a concern by stakeholders whereas other types (e.g. volumetric systems) are. Given that building regulations are intended to be indifferent to the method of construction then MMC should have no effect on the evacuation strategy. However, current regulations, guidance and test methods are sometimes geared towards traditional building methods which can constrain the use of some types of MMC.

Modern methods of construction are seen to offer some considerable advantages in construction cost, speed and sustainability. One participant sees a higher demand for modular construction because these have less reliance on expensive and unreliable local tradespeople, and they also omit the need for the storage of construction material on limited site spaces. However, there were some concerns expressed by participants about the uncertainties surrounding their fire performance and how that might differ from traditional construction methods. Participants felt that there was a lack of rigorous testing to demonstrate the safety of in some instances.

With modular construction, there was confidence that such buildings could be made safe, but there was some scepticism about whether they would be made safe. Those constructing buildings may understand the issues of compartmentalisation for traditional concrete or steel but may not be experienced in doing the same for modular systems. Volumetric construction inherently has a greater number of voids, with a correspondingly increased amount of fire-stopping required. Manufacturers of modular units are focussed on manufacturing quality units, rather than the difficulties of assembling them into a safe building. It was felt that manufacturers lack experience of building high-rise residential buildings and that information suitable for lower rise modular developments has been applied to taller developments on the assumption that it will be appropriate. Testing of completed modules, and sections of modules show that these can demonstrate adequate compartmentalisation, but a completed building needs extensive fire-stopping and the continued integrity of each module throughout the building life to maintain that compartmentalisation. Currently there is no structured method of ensuring that fire-stopping is installed correctly. There should be a formalised process of verifying each firestop which includes accreditation, documentation, photographic records, etc.

One participant that is encouraging the use of MMC because of its programme, financial and site space efficiency benefits pointed out that its success depends on the companies and individuals on site and how well the documentation is recorded. New building projects will be to BIM level 3 for asset management and fire and rescue service use. However, another participant responsible for commissioning residential buildings described their recent decision not to consider designs employing modern methods of construction (such as mass timber, modular construction etc) because of the lack of proven safe operating experience. Resident and other stakeholder confidence was a crucial factor in this decision-making.

A1(3).2.8 Financing and tenure

There was discussion by participants on the different approaches to the financing of buildings including build-to-rent [7] within the private sector, build-to-sell and those intended for the social rented sector. Similarly, participants discussed the multiple range of housing tenure conditions including freehold, private leasehold and social rented. In addition, there were discussions around permanent residents, short-stay options and ‘apart-hotels’, each of which could occur in the same building and may affect the evacuation strategy along with the expected occupant behaviour. Participants mentioned there is pressure in the private rental sector to increase the number of flats off each corridor which puts more onus on the function of staircases and smoke ventilation systems.

The financing and tenure options lead to situations in which flats are allocated by a central body (such as social housing providers) through to being made available on the open market. In some cases a single building may have a mixture of tenure conditions. These options affect how residents come to reside in particular parts of the building – either through personal choice or by allocation through a third party. One participant is changing their letting policy on who should live in certain buildings if they cannot self-evacuate.

The tenure conditions can present challenges when wishing to gain access to flats for maintenance etc. There also was discussion on whether all tenure holders who are jointly accountable for communal spaces would be responsible for paying for changes to accommodate residents whose ability to evacuate had changed over time. Having mixed tenancy conditions in one building would add to the complexity.

A1(3).2.9 Modification of buildings

Building renovation was briefly discussed, noting that this is difficult when residents are in place. There was more discussion on the re-purposing of older buildings particularly where previous office and/or retail occupancies might be converted into residential use. One participant expressed that although there is no demand for shared office space in new residential construction as the value per square metre of residential is much higher than for offices, the conversion of older buildings might include shared office areas. It was noted that buildings that were previously offices may already have the benefit of multiple vertical escape options. Conversely, there was concern about fire spread through full height glazing / curtain walls and narrow spandrel zones that could affect flats higher up the building should those features be retained. The retrospective adaptation of existing buildings can affect confidence that what is built is what was intended and there must be ways to demonstrate that this is the case. Sometimes, however, it is more cost-effective to demolish a building and re-develop the site.

In either case, although technology is proving useful in maintaining the ‘golden thread’ when renovating or re-purposing buildings, there must be controls to limit unauthorised modifications and mitigate badly executed sanctioned modifications.

A1(3).2.10 Fire protection measures

At least one participant prefers to use passive systems (e.g., doors) rather than active ones (e.g., fire curtains) because of the costs of verification, testing and maintenance. Their focus was on using simple systems rather than taking a value engineering approach. Fire protection measures need to be robust enough to deal with the possibility of damage caused by residents. Another participant suggested that the fire resistance expectations in new construction should be higher than at present and was keen for less reliance on specific fire engineering design but instead to have a more prescriptive approach. It was also noted that highly engineered systems (e.g. ventilation systems for single stairways) are being *“…designed for compliance and not for occupation…”* in which it was clear that after handover building operators have not understood the significance of these systems and have therefore not managed them suitably.

The installation of sprinkler systems was discussed by several participants (noting that ADB has recently been revised to recommend systems be fitted to residential buildings over 11 m tall). There was a sense by one participant that the installation of sprinklers will have a major impact on reducing the likely severity of fires. Even in the case of fires that may start on a balcony, sprinklers will mitigate fire spread into the building. Another participant considered sprinkler systems to be a supplement to other building elements such as

compartmentation rather than being a ‘replacement’. When discussing property protection, it was noted that sprinkler systems also satisfy the objectives of insurance providers.

It was observed that sprinkler systems are being fitted to new developments regardless of the guidance etc. as this was seen as both enhancing the level of safety to residents along with reducing the investment risk (see Section A1(3).2.6). However, as already noted when discussing tenure conditions in Section A1(3).2.8, there was concern with their maintenance and the need access to resident flat. One participant has also received complaints from residents about post-sprinkler activation water damage. Other than as previously discussed in Section A1(3).2.2, water mist systems were not otherwise mentioned except where one participant expressed their lack of confidence in their performance.

The provision of stairs was raised by several participants. Having additional stairs is very useful during the construction of a building but it can challenge the overall economics of a project. When a building is occupied, it was felt that a single stair building would be acceptable if there was confidence in the other fire protection measures. However, one housing provider participant felt that high-rise residential buildings with a single means of escape was a thing of the past and would look to provide a second means of internal or external escape for buildings greater than 11 m tall. Another housing provider participant is already fitting two stairs into their plans for new high-rise residential buildings as a matter of course in case the fire and rescue service decides to evacuate the whole building.

It was noted by one participant that some buildings are looking at implementing evacuation alert systems that can be operated by the fire and rescue services should this prove necessary in a severe fire. Introducing systems could signal either a lack of confidence in primary systems (e.g. compartmentalisation, sprinklers) or a tolerance of failure of those systems. Similar to sprinkler systems, concerns were raised about access for the maintenance of automatic fire detection and alarm systems. More broadly the issue was raised on how people on terraces and balconies might be alerted to fire given it is unlikely that automatic fire detection and alarm systems will be located in such areas. For example, what if a person was asleep on a balcony with the doors closed – how would they be aware of a fire in their building? A dissenting view on the need for alarms expressed the opinion that including provision for this type of additional provision, reflected a concern that the primary safeguards (i.e. compartmentalisation and sprinklers) were not reliable or effective enough to provide sufficient confidence without a back-up.

One participant was particularly concerned that an evacuation strategy should not rely on escape windows as it is difficult to envisage how these can be used by those with disabilities, carrying young children, etc. Instead, early detection through the installation of automatic systems allows residents to be aware of a fire and to take appropriate measures.

Finally, fire-fighting equipment has changed considerably in recent years, as have some building technologies, but guidance on building design has not taken these into account. Designers are primarily concerning themselves with evacuating people from the building, but not always concerned about the fire-fighters who will be entering the building and who are often seen as an afterthought. For example, lobby spaces may not be adequately sized

for the current fire-fighting operations and ventilation systems which remove smoke from corridors rather than flats, make it more difficult for fire-fighters entering the flats.

A1(3).2.11 Energy supplies

Participants noted the move to make new buildings low carbon with more electric charging points, solar panels, ground source heat pumps being specified. It was felt by some that these would not need any significant additional safety measures although there was also an opinion from others that novel systems have been implemented without considering their impact.

It was pointed out that reducing the ignition sources in the building increases safety. For example, the trend towards more low voltage appliances (LED lights, mobile phones, etc.) may see a wider use of low voltage circuits which could limit the likelihood of a fire starting. Participants are examining the option to restrict higher voltage circuits and appliance to specific parts of a building that may allow for them to be fire separated from other areas.

The benefits and risks of electric vehicle charging points was discussed and it can be important to position them appropriately with respect to the building, e.g. through compartmentation between car parking and residential areas. The It was suggested that those living in high-rise buildings in cities might not need cars and therefore charging points will not be necessary. However, the demand for charging electric mobility aids is likely to increase and so these should also be contained so that the compartmentalisation of flats can be relied upon.

One participant suggested that natural gas is hardly used in newer high-rise buildings and all cooking is electric. However, another participant is still building blocks of flats with individual gas supply but looking to phase this out and similarly there was an awareness of gas boilers still being installed by short-term investors even though they might have to be removed as a result of the Future Home Standards initiative [8]. In some cases, heating systems may use natural gas for a central heat-raising unit rather than for individual flats.

The use of hydrogen gas was briefly mentioned in passing by several participants and some saw this as a viable option in the future but for others it was not something they were considering. It was suggested that there are cases in which hydrogen fuel cells are already being used for certain functions and these could either initiate a major incident or could be affected by a major incident.

A1(3).3 Review of published articles

A1(3).3.1 Architectural form and building use

The literature contains papers that discuss the development of the architectural form of high-rise buildings and the structural system design. For example, Alaghmandan et al. [9] note that the number tall buildings and their height across the world show an increasing tendency. The macro and micro level aerodynamic form of buildings has evolved to include curvilinear, tapering, and twisting geometries. Structural material selection is shared equally between concrete or composite systems with only 15% using steel.

Similarly in the paper by Szolomicki and Golasz-Szolomicka [10] the authors consider the various forms of high-rise buildings, and the predominance of concrete and composite materials over steel structures. The authors discuss the application of systems to generate and save energy. The paper suggests that mixed-use occupancy high-rise buildings are becoming increasingly popular. However, not only such buildings are more difficult and costly to erect but they also present design complexity around pedestrian flows, segregation of users, and building code provisions.

A1(3).3.2 Modular construction

Modular construction is covered in a number of articles published by Inside Housing (IH). An article from November 2016 [11], commenting on the start of construction of Europe's largest residential modular tower, quotes the Chief Executive of the developer as saying "*If we're able to scale up modular construction it has the potential to help solve London's housing crisis. Factory-built modular homes are quicker to build than conventional buildings and result in significantly less disruption to local residents – with 60% fewer trucks coming to sites and 90% less waste.*" However, some articles point to uncertainties in the integrity of such construction and there are examples of modular developments [12] that have been found to have widespread defects relevant to fire safety. It is not clear whether the defects in these examples are directly related to the modular nature of the building's construction, but other articles comment on concerns about embracing modular construction [13] without an understanding of the risks involved. Similarly, Zurich Insurance raised concerns that "*…serious problems … can be experienced when implementing modern methods of construction (MMC), particularly issues relating to … the increased risk of … fire damage … and a greater degree of fire spread*" [14]. It seems reasonable to imagine that such concerns would undermine confidence in a stay-put evacuation strategy.

A1(3).3.3 Conversion of commercial properties to residential

Whilst it has been a trend for some time, conversion of commercial premises to residential use has been given a boost by the effects of the covid pandemic. The retailer John Lewis announced that it "*…intends to convert unused shop space into affordable ho*mes" [15], and

the permitted development process has seen office and other commercial properties converted into housing. The results of this type of development have had a mixed reception. The government's Housing Minister defended the approach [16] but admitted that some poor-quality homes had been delivered. The article is not explicit about the way in which these homes are poor quality, but the size, layout and lack of natural light are problems with such developments referred to elsewhere. There is no explicit suggestion that there is increased risk from fire in these conversions, but it is clear that since commercial and residential buildings are designed for very different end uses, there will need to be careful consideration given to the fire strategy employed. A study for the RICS [17] noted that whilst some high-quality developments were observed, there were serious concerns about the quality of others including the fact that "… *some had barely any changes made to convert them from office to residential use, with concerns about fire safety and noise insulation*".

A1(3).3.4 Use of timber construction

Timber construction, using cross-laminated timber (CLT), has been an increasingly popular material for housing developments providing a sustainable alternative to concrete and steel. However, its use in high rise developments has been limited by the in-effect ban on combustible materials on external walls above 18 m. Whilst the timber industry has embarked on a testing programme [18] to demonstrate its fire safety, others have pointed out potential vulnerabilities [19] when exposed to fire. If such construction cannot be shown to provide compartmentalisation or prevention of fire spread, it will be necessary to implement an evacuation strategy which is compatible with this behaviour.

A1(3).3.5 Airspace development

With the high price of land in many cities, developers are looking to utilise the 'airspace' above their existing properties. This might take the form of adding extra floors into the existing shell of the building or utilising modular solutions [20], whereby modular units are essentially added to the upper floors. Some of these modular units will include additional staircases and structural support for the new dwellings. Where these modules are separate from the existing building, it is important that evacuation considerations are taken into account. Fire spread between the existing building and the new construction may be complex and evacuation routes may be non-intuitive, particularly if there is no connection with the existing building.

A1(3).3.6 Short-term rentals

Short-term rentals, such as Airbnb, are a large part of the accommodation provision for the UK and worldwide. In London there are over 77,000 listings [21], of which 43,000 are entire homes and 34,000 are rooms or shared rooms. An investigation into illegal rooming house networks in Melbourne [22] found cases of city apartments being rented to foreign workers, students and backpackers. Living rooms were being used as bedrooms by dividing spaces with curtains or wooden frames.

Such lettings are typically for just a few days or weeks and will be in residential, rather than hotel, accommodation. Where they are in high-rise accommodation, temporary residents are likely not to be familiarised with the evacuation strategy and could anticipate a hotel-style immediate evacuation approach. Whilst this may not be an issue where there are just a few short-term lets, but as the number grows, it is possible that the problem of 'confused' evacuation could become significant. Higher than expected numbers of occupants might be in a building where multiple flats could be used to house more people than designed for. Recent research has been carried out to assess occupant density values in residential building in England [23] although the work recognised "…*that not all occupants necessarily sleep in bedrooms and that the number of occupants registered to a dwelling is not always representative of its occupancy at a given time*."

A1(3).3.7 Design, construction and maintenance defects

Examples of construction or design defects which affect a building's performance in fire are presented in a number of articles. In one report [24], a timber-framed block is described as having cavity barriers that 'contributed nothing to control the fire' that spread through the building, causing almost complete destruction. It was concluded that these cavity barriers were inadequately designed. Whilst not a high-rise building, the report highlights the danger of poor design generally and the implications that this may have for assumptions about fire spread which affect evacuation strategy. A study of over 400 tower blocks [25] showed that over 60% had defective fire doors, ventilation systems, emergency lighting or fire compartmentalisation. One housing association reported fire safety defects [26] in all 86 of its properties, ranging from minor to requiring multi-million pound remediation programmes. These problems included "*serious and widespread compartmentation breaches*", "*flammable and/or sub-standard cladding installations*" and "*missing or poorly installed fire stopping and fire breaks*". Again, it is not clear how many of these are high-rise, but they are indicative of issues facing the industry generally. In a recent fire [27], the smoke detection system failed activate and close fire doors, allowing smoke to fill communal areas.

A1(3).4 Impact on evacuation

The key findings from the discussions with the various industry professionals of the effects on evacuation of high-rise residential would suggest the following:

1. As an evacuation strategy, *stay-put* is not always well understood by residents and even by many professionals. Whilst it was generally felt to be appropriate for most residential situations, it was recognised that its success and residents' confidence in its effectiveness relies on a number of factors, including:
    a. Effectiveness of compartmentalisation;
    b. Use of sprinklers;
    c. Effective smoke management; and
    d. Resident awareness of required responses
2. Engagement with residents on the building evacuation strategy is crucial to ensure not only that all components are understood, but that this understanding frequently refreshed and reinforced. There is a trend of finding more effective ways in which to engage residents in their understanding of the evacuation strategy. Communicating the evacuation strategy to occupants is likely to be difficult where buildings are being used for short-term rental accommodation.
3. There is increasing use of shared amenity areas, such as roof terraces, common rooms, kitchen/dining rooms. However, there was a considerable range of opinion about how the evacuation strategy for such areas should be managed, particularly for those shared areas located higher up the building.
4. Modern methods of construction offer many advantages such as speed of construction and cost-savings. However, some of these systems, such as modular construction, rely for their fire integrity on extensive fire stopping around each module to preserve the compartmentalisation integrity throughout the building life. Experience has shown that for this to be true, there must be a greater focus on extensive, independent verification during construction than is currently the case.
5. Investor confidence and perceived futureproofing is an important factor in decision-making around safety and evacuation measures. In some cases this pushes designers to incorporate features, such as a second staircase and/or sprinkler systems, that would not normally be required by guidance or driven by the fire strategy.
6. The design of high-rise residential buildings needs to recognise that the needs of residents may vary during the time they live in the building – whether that be permanent or temporary impairments, the need to care for dependants etc. Changing population demographics make it more likely that high-rise accommodation will house elderly residents with reduced mobility, who will require the use of lifts for evacuation. It is recognised that are problems with providing 'triaged' evacuation for buildings without a permanent custodian.

A1(3).5 References

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