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The 'Safety Gap' in buildings: Perceptions of Welsh Fire Safety Professionals

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Abstract

This paper presents evidence of a 'Safety Gap' in buildings for fire performance and reviews different approaches to achieving Fire safety in England and Wales, UK, for a Research & Enterprise Innovation Funded project at Cardiff Metropolitan University. One aspect of the safety Gap is for potential defects in construction from incorrect installation, missing, inappropriate or defective components, that make up compartmentation, fire stoppings and workmanship errors, to enable rapid smoke spread across compartments, so preventing the safe evacuation of occupants. A questionnaire survey was conducted with fire rescue and safety professionals in South Wales, UK in 2016. Results show that more than 75% of the respondents think that in-built performance of fire safety measures including compartmentation are difficult to assess during fire risk assessments and fire risk audits, using current visual inspection methods. The majority of the participants agreed that a non-intrusive and non-destructive test method could help in ascertaining the integrity of building compartmentation and in-built performance of other fire safety measures and to ensure the safety gap is not present. It is discussed that these findings give fire industry backing for the non-destructive test, measurement and reporting protocol that the first two authors of this paper are developing for assessing the effectiveness of active and passive fire protection systems in buildings. This paper will be useful for academics, building owners and landlords, developers and fire and rescue services investigating and involved in ensuring the fire protection of buildings and of the health, safety and wellbeing of their occupants.

Peer-review under responsibility of KES International.

Keywords: Safey Gap; Fire safety measures - Compartmentation; Fire risk assessment & fire risk audit; Occupant safety and wellbeing.

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1. Introduction

In the UK, 76% of fire related fatalities occurred in dwellings in 2015/2016 [1]. Non-fatal casualties in dwelling fires were 76% while in other buildings it was 14% [1]. In England in 2014/2015, 40% of fire-related deaths were caused by 'gas or smoke' while 'burns' caused 33% of fatalities and another 20% by both 'burns and gas or smoke [ibid]. Fire development inside buildings is generally divided into four stages: growth stage, flashover stage, post flashover stage and decay stage. The fire starts with a growth period which either changes to a rapid flashover stage or starts to decay. If flashover happens, the fire grow into fully developed stage before it starts to decay [2, 3]. Smoke generated during fire can contain dangerous gases such as carbon monoxide, hydrogen cyanide, hydrogen chloride, hydrogen fluoride, carbon dioxide and poses threat to life of occupants and fire-fighters [4]. Sometimes, smoke deposits and their subsequent odour damages the building to an extent where it has to be demolished [5].

The integrity of passive fire protection measures, such as compartmentation (separating walls, floors and ceilings) are not always assured. In 2010, the Department for Communities and Local Government (DCLG) found that in some of the real fires incidents in building's compartmentation could not restrict the spread of smoke into adjoining dwellings, or through hidden cavities [6]. These hidden cavities also have the potential to affect unwanted air leakages impacting upon sound pollution and heat loss. An investigation carried out by the UK's Building Research Establishment (BRE) on fires in different types of building reported to the DCLG between 2003 and 2013 [7,8] found that 32% of inspected fires had issues of fire spread due to either defects in compartment construction details or inadequate or poor condition of fire stoppings. The main problems identified were voids in roof compartmentation and issues with cavity barriers in concealed spaces [ibid]. These findings coincide with the results of the case studies from Littlewood and Smallwood (2015) and (2016) [9, 10]. In 2015/2016, 31% of building fire audits carried out by fire and rescue services using current methods revealed that fire protection measures (passive and active) are not satisfactory in the investigated buildings in the UK [1]. Thus, there is an urgent need to investigate the extent of these fire and smoke spread issues within new and existing dwellings in the UK and also identify further improvements in the legislation to ensure the in-built performance of fire safety measure in buildings. This is particularly important in Wales, since the Welsh Government have recognized that citizens should be able to live and work in cohesive communities that are healthy, safe and resilient through their Well-being of Future Generations (Wales) Act (2015) [11].

This paper examines the currents approach of England and Wales in the UK towards achieving fire safety in buildings and the implications of potential failure of fire protection measures including compartmentation, which could also affect acoustic and thermal performance. Further, the paper presents the results of a preliminary study of the perception of fire and rescue experts in Wales, toward the effectiveness of compartmentation in resisting the spread of smoke and fire and whether fire audits of buildings under construction and those already constructed should include a test methodology to demonstrate compliance with Fire Performance Legislation and Regulations.

2. Fire safety approach in buildings in England and Wales

People spend much of their time in buildings and as such the term fire safety is referred to as preventing fire, restricting the spread of smoke and fire, and extinguishing a fire, and providing quick and safe evacuation [12]. In England and Wales, current fire safety design has developed from two legislations; i) The Building Regulations ii) The Regulatory Reform (Fire Safety) Order 2005 (Fire Safety Order). Approved Document B (Volume 1) of the England and Wales Building regulations provides basic guidance to achieve compliance for fire safety in dwellings. Fire safety in buildings is achieved by providing fire protection measures (active and passive) which include for example fire doors, fire alarms, and compartmentation between units for restricting the spread of smoke and fire for minimum 30 or 60 minutes depending upon the type of building. An alternative design approach is available in BS 9999:2017 'Fire safety in the design, management and use of buildings. Code of practice' [13] applicable to both new and existing buildings which takes into account the management of fire safety in buildings and the control that can be achieved through management processes to ensure a reasonable and, perhaps, more flexible approach to fire safety. BS 9999:2017 determines the fire safety solution based on the overall building risk profile taking into account the occupancy characteristic and fire growth rate. BS9991:2105 'Fire safety in the design, management and use of residential buildings. Code of practice' [14] for residential buildings including specialised housing providing care facilities. However, all design approaches or guidance rely on the laboratory testing of products carefully installed to meet the regulatory requirements without warranting the in-built performance. However, during construction if an operative has a lack of knowledge and time or resource constrains, then sometimes components and products may not be installed as specified, which can lead to construction defects that affect a building's performance. The Performance Gap in buildings has been well documented in the UK, principally for less than adequate thermal performance, where operational performance is considerably less than as-designed due to problems that occur during construction [15].These gaps or defects can also affect the in-built performance of fire safety measures, which Littlewood et al. deem as the 'Safety Gap' [5], and they believe could also be detrimental to acoustic performance. Indeed, in a post occupancy evaluation study of occupants in multi-storey apartment buildings, Littlewood found that one of the greatest complaints from dwelling occupants in the UK is noise pollution [16]. This noise pollution could be caused by the same defects that cause problems with the Performance Gap and the Safety Gap.

Currently in the UK, to meet acoustic performance and thermal performance then special construction details (robust and accredited) can be specified. In addition, to determine compliance with minimum and as designed acoustic performance and thermal performance standards as set out in Approved Document E (acoustic) and L (thermal) of the England and Wales Building Regulations there are physical test methods which are undertaken [17, 18]. However there are no approved construction details or a physical test method to determine the effectiveness of active and passive fire prevention measures and compliance with Approved Document B, of the England and Wales Building Regulations [19]. In the UK, regulatory construction quality that impacts upon fire performance is assessed by either private (consultants) or public (government) building control professionals; in addition to operatives from fire and rescue services and developer's construction quality inspectors. All these inspectors conduct visual inspections of construction details as installed. However, due to the hidden nature of construction details behind layers of materials and components, Littlewood and Smallwood [9, 10] and Littlewood et al. [5] believe that a visual inspection approach is inadequate to identify gaps and defects in the compartmentation construction and fire stopping details, specifically in concealed spaces. There is thus an urgent need to review Approved Document B of the England and Wales Building Regulations to take into account the lessons learned from different incidents of building fires in the UK and also that of research at Cardiff Metropolitan University [5, 9, 10, 19]. This is further supported by the UK All-Party Parliamentary fire and rescue group, and any further delay can put lives of occupants in buildings at risk [20].

The Regulatory Reform (Fire Safety) Order 2005 applies across England and Wales to virtually all existing buildings, places and structures other than individual private dwellings and including common parts of blocks of flats and houses in multiple occupation (HMOs) and maisonettes. Under the Fire Safety Order, anyone who has control of premises is required to carry out fire- risk assessment and manage the identified fire risks. Fire rescue authorities are the main enforcing authority and carry out fire risk audits in buildings to ensure the existing buildings are meeting requirements of the Fire Safety Order. Risk Assessment is mainly a non-destructive assessment due to it destructive and disruptive nature, but in rare situations a destructive examination in cases of serious doubt about the structure is undertaken [21]. Given that regulators such as building control (new buildings) or fire and rescue authorities (existing buildings) are not always able to thoroughly check the installed performance of in built fire safety measures, the assurance of achieving relevant regulation or standards is not known. Even small defects and gaps in compartment construction contribute to quick spread of smoke and fire. Cheung et al. [22] demonstrated through numerical investigation that a gap of few extra millimeters between fire rated door panels and wall or floor can lead to increased volume of hot smoke spread between compartments and possibility of cold air re-entraining back into fire compartment. It has been shown in studies by Littlewood and Smallwood [9, 10] that defects in compartmentation lead to unexpected spread of smoke much earlier than the time frame required by Approved Document B.

3. Fire 'Safety Gap' and its implications for occupants

For an effective fire compartment, each compartment must be separated from other compartments (so this would be apartments in a multi-storey block of flats) to ensure a defect free continuous construction. However, effectiveness of fire compartmentation can be compromised due to defects in construction details that make up compartmentation and fire stopping within concealed spaces [5, 7, 8, 9, 23]. This can lead to early failure of compartmentation and rapid spread of smoke and toxic gases into adjacent compartments, which could have tragic effects on the safety of occupants in an actual building fire. These defects arise due to number of reasons including: errors in workmanship and construction site practices, incorrect fitting of components, missing components such as insulation, inappropriate materials/components for passive fire-protection, short term fixes or improvisations, poor installation of fabric components, damage to components during maintenance and alteration work and inadequate transfer of construction details from Architect/Design team to Building Contractor's site operative.

The impact of these defect was initially identified during investigations of thermal performance of buildings where actual thermal performance of buildings is less than the designed and also predicted performance and named as the 'Performance Gap' [15]. A number of studies have reported that these defects could also affect the fire performance in buildings. Between 2013 and 2015, when Littlewood was using his in-construction testing (iCT) [24] protocol to assess the effectiveness of construction details to meet thermal performance standards [18] in dwellings by undertaking air permeability tests combined with whole dwelling cold smoke tests he also discovered by chance that defects were also detrimental to passive fire protection measures [9, 10]. Littlewood termed it as the 'Safety Gap'. In one case study building (two semi-detached houses on two-storeys) had an exterior wall of timber frame with a cavity and brick cladding construction; where unwanted air leakage pathways from defective window and door seals were detected. Additionally, researchers also discovered that smoke spread rapidly into an adjoining dwelling, through an electrical socket in the party wall. This party wall was built to provide smoke/fire resistance for a 30 minute, however the compartmentation seemed to fail in less than five minutes. A second example of smoke spread between the dwellings in a different case study (also timber frame construction, but with an exterior render finish upon blockwork) was at the eaves level in the roof space. This had examples of breaches in vertical compartmentation (upwards from dwelling to roof space), also horizontal (through fire stopping from one roof space to another), in ducting (around the boiler flue outlet to the external environment) and vertically/horizontally where the smoke was found to be escaping through an extractor fan mounted on the exterior wall, in a bathroom, in a dwelling diagonally below the test flat. The final case study was of a UK traditional outer brick, cavity and inner block exterior wall (with thin bed mortar system) where there were breaches in vertical and horizontal compartmentation from a test dwelling (on the first floor with one floor below and one above). The breaches in vertical compartmentation affected dwellings above, and then above this into the roof space, and also below into another dwelling on the upper storey and into the roof space above. The horizontal breaches in compartmentation also affected fire stops in the cavity with dwellings affected on the same floor [ibid].

In 2015, a housing association with the Sussex Fire Service succeeded in a high court action against a building contractor for a fire that occurred in a care home in 2013 that they built in 2001, where 30 occupants had to be evacuated with serious injury [25]. Fire services were able to demonstrate that compartmentation failed to restrict the smoke and fire spread for 60 minutes, and as such they were prevented from tackling the blaze before rapid fire engulfed the building across six storeys. In 2017, London Fire Brigade has started a prosecution against the Southwark council under the Regulatory Reform (Fire Safety) Order 2005, after the fire spread through Lakanal House in 2009, leading to the deaths of three women and three children and council recently pleaded guilty and paid a fine of £570,000 [26]. Littlewood has also demonstrated that in many cases active systems such as smoke and fire alarms do not actually work in practice or work effectively. In England, in 2013-14, almost 2.5 million households (11%) either did not have a smoke alarm or one that was not working, while nearly 300,000 households (1%) were not aware if their smoke alarm was in working condition [27]. In 2014-15, Fires where a smoke alarm did not work or did not raise the alarm, accounted for 38% of all dwelling fire fatalities [28]. A study showed that over 80% of the sleeping children (aged between 2 years to 13 years) tested did not respond to the sound of the industry standard smoke detector [29]. The study was conducted following a house fire in which 6 children lost their lives in 2012. The above evidence demonstrate that there is an urgent need of testing in-built performance of any active and passive fire safety measure installed in buildings to ensure its effective working in real fire scenarios.

4. Methodology - Fire and rescue professional's perception

4.1. Questionnaire study

As part of Littlewood's and Cardiff Metropolitan University's ongoing research investigating the development and implementation of a test method for determining the effectiveness of active and passive protection measures in general needs dwellings, a questionnaire has been developed and received ethics approval from Cardiff Metropolitan University in November 2016. The questionnaire is to investigate the perception of Fire and Rescue professionals in England and Wales towards the effectiveness of passive fire protection measures (compartmentation and fire barriers) in buildings to prevent smoke and fire spread within stipulated time frames such as 30 or 60 minutes as set out in Approved Document B. These timeframes are to allow occupants to safely evacuate a building in the event of a fire and also for fire and rescue services to tackle the fire and assist in the evacuation of the occupants. In addition to investigating whether Fire and Rescue professionals confirm the authors' opinions that there needs to be a mandatory test method to determine compliance with Approved Document B and in particular the effectiveness of active and passive fire protection measures.

A preliminary study was conducted as a workshop in November 2016, at the annual general meeting of the Institute of Fire Engineers in Wales, which included a range of Fire and Rescue professionals. A structured questionnaire was developed in order to collect data on the effectiveness of compartmentation against the spread of smoke and fire, and details of methods currently used to assess their effectiveness. Both close-ended (multiple-choice questions) and open-ended questions were included [30]. An Information sheet was provided with illustrations from the literature and case studies identifying the issues of potential defects with compartmentation from Littlewood's work to date [9,10].

The questionnaire includes a number of sections, including: general background; building defects and impacts upon fire performance and occupant safety; and fire safety inspection process related to risk audit or home safety visits. The invitation for the participants included information about the authors' current research project and how the information from the questionnaire would be used. Furthermore, it was made clear that participation would be anonymous, and that the answers will be treated confidentially. Analysis of qualitative data in the form of text responses was carried out using NVivo 11 data analysis software and is documented in section 5.4.

5. Questionnaire Results

5.1 Sample

A total of 16 respondents participated in the initial questionnaire study, out of 18 attendees at the 2016 annual general meeting of the Institute of Fire Engineers in Wales. The first two questions asked the respondents about profession and location and the respondent's professions included five front-line fire fighters, nine fire safety inspecting officers, four fire risk assessor and one of each of the following: chartered fire engineer, building control surveyor, health and safety manager, retired fire officer and also a retired fire inspector. All of the respondents were located in Wales, with six, five and one each from Swansea, Carmarthen and Port Talbot, Newtown, Llanelli, Neath and Carmarthenshire. This indicates that the majority of respondents represented the major conurbations of Wales with circa 600,000 inhabitants against a welsh population of circa 3,000,000.

5.2 Relative danger of smoke, fire heat and particulate matter

The second section of the questionnaire aimed to gather information about the relative danger of fire and smoke to occupants' safety and effectiveness of compartmentation. Figure 1 below, shows the respondents' answers when asked to rate (on a scale of 1-10) the relative danger of smoke gases, fire heat and particulate matter to the safety of occupants in the case of fire in a building. It can be seen that smoke gases were rated seven or above by all respondents and approximately 44% of respondents gave the highest rating of 10, while 12%, 31%, 19% rated smoke gases at nine, eight and seven respectively. The relative danger of heat from fire was given the rating of 10, seven and five each by 25% of respondents. The relative danger of particulate matter received the highest rating of 10 by only 19% of respondents while 31% respondent opted for the rating of eight. These results indicated that smoke gases were relatively more dangerous to the occupant's safety in case of fire in buildings.

5.3 Effectiveness of compartmentation

The participants were then asked about whether fire/smoke is confined within a building compartment for minimum time frames (30 or 60 minutes) as outlined in Approved Document B. Fifty percent of respondents expressed that fire/smoke is not confined in building compartments for the prescribed minimum time frames, although another 50% did not agree. The next few questions were a mixture of close ended and open ended questions where participants were asked about the effectiveness of building compartmentation to provide fire/smoke resistance for minimum time frame and were given the options to write answers in response to questions by giving further details. All participants stated that building compartmentation or fire stoppings can fail before minimum time frames, and fire/smoke can spread to different storeys of the same building or different units within the same buildings before 30 minutes. All participants agreed that defects in building compartmentation can cause problems in fire/smoke spread.

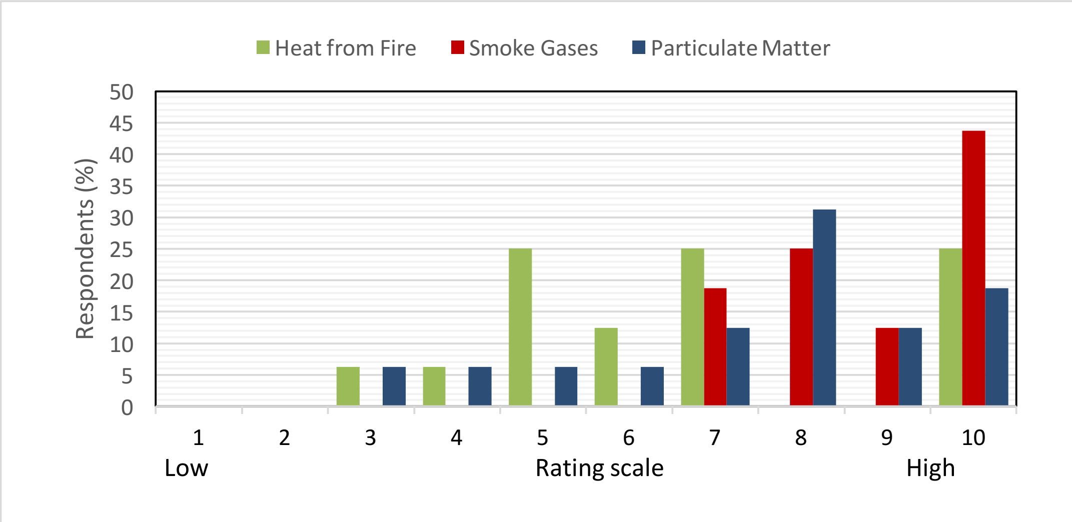
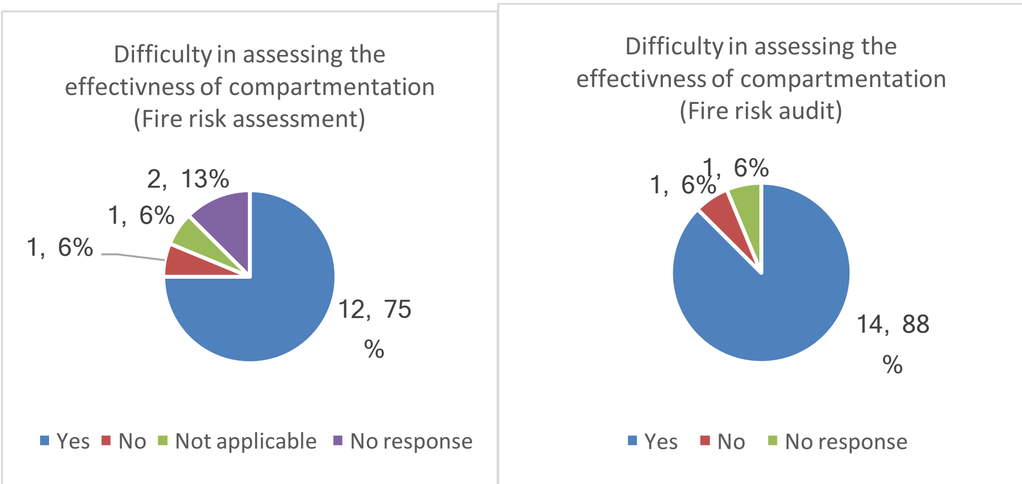


Fig. 1. Relative danger of smoke, fire heat and particulate matter

5.4 Inspection of compartmentation

This series of questions was to determine whether the building compartmentation integrity is inspected during fire audits, home safety inspections or as a part of risk assessments and if so what are the different methods currently used. The majority of the respondents (69%) responded that they inspect building compartmentation during fire safety audits or home safety checks. Figure 2 below shows the response to the question ‘Is it difficult to assess the effectiveness of building compartmentation as part of fire risk audit and fire risk assessment’. 75% of the respondents find it difficult to assess the effectiveness in fire risk assessments, increasing to 88% in fire risk audits.



(a) (b)

Fig. 2. Difficulty in assessing the effectiveness of compartmentation as a part of (a) risk assessment (b) Fire risk audit

The results illustrated in Figure two show that majority of the respondents face difficulties in assessing the integrity of building compartmentation to meet the minimum time frames as stipulated by Approved Document B. This difficulty may result in uncertainty in the integrity of building compartmentation especially the fire and smoke barriers in concealed spaces. When asked about inspection of fire and smoke barriers in concealed spaces in buildings, 25% of respondents never inspect concealed spaces while 63% inspect the concealed spaces. Among all of the respondents who inspect the concealed spaces, the majority rely on limited non-intrusive visual inspection alone while a few use it in combination with information from other sources such as trade literature and thermography. Based on the respondents' text answers a thematic search for word 'inspection' was carried out in NVivo data analysis software. For this purpose written responses were transcribed in the NVivo 11 software and thematic text searches were conducted. A tree map was generated to highlight the word 'inspection' and understand their context described by respondents. Figure 3 below shows the results of thematic word search 'inspection' revealing that mostly respondents referred to visual, non-physical and non-intrusive in context to the inspection of building compartmentation.

The next question asked participants to rate their method of building compartmentation inspecting in terms of providing adequate information, to help make decisions about building compartmentation integrity and a rating scale of 1 to 10 was used, where rating of 1 indicates not-adequate and rating of 10 shows adequate. All the respondents who inspect concealed spaces gave the rating of five or less except one who gave the rating of six to his method of using visual inspection only. Three respondents rated their method of inspection inadequate giving rating of one while one other respondent rated their methods of inspection between two and five.

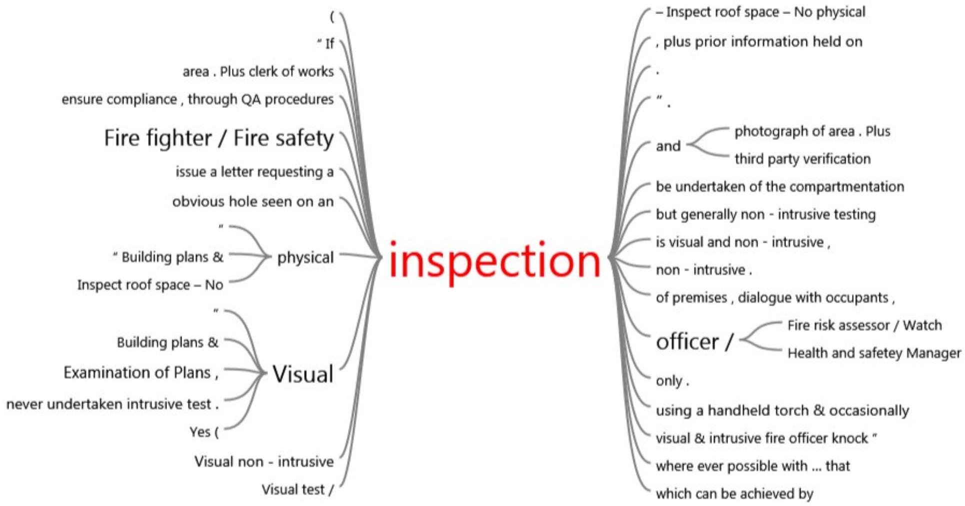


Fig. 3. Tree map of thematic word search 'inspection' in NVivo data analysis software

5.5 Testing of compartmentation

The final set of questions explored the effectiveness of a non-intrusive and non-destructive test method which does not damage the structure and contents of buildings, and could be used to ascertain the integrity of building compartmentation including concealed spaces. It was found that 88% of the participants are in favour of a non-intrusive and non-destructive test method that can help in assessing the integrity of building compartmentation, whereas only 12% of respondents were not convinced. Table 1 below shows the number of respondents who wrote different phrases/words in response to further questioning to ascertain if this proposed non-intrusive and non-destructive method could enhance visual fire risk assessments for new building and visual fire audit assessments of existing buildings.

Table 1. Respondent's response about non-intrusive and non-destructive method could enhance visual fire risk assessment

	"Yes"	"Most Certainly"	"Definitely"	"Greatly"	"Difficulty in assessing time"	"Smoke test"
Enhanced visual fire risk assessment for new buildings	5	2	1	1	1	1
visual fire audit assessment or existing buildings	8	1	2	-	1	-

The results indicate that respondents felt that there is a need for a non-intrusive and non-destructive test method which can help in identifying issues in compartmentation which may lead to its failure before minimum required time leading to concerns of safety of not only occupant but also the safety of fire fighters attending the building fire. In response to the question to determine which practioner should conduct the non-intrusive and non-destructive test method, the majority of respondents (63%) determine that it should be Fire Engineers, or 12% and 19% Building Surveyors or an independent authority respectively. It is not surprising that respondents determined that Fire Engineers should conduct the test, since the sample group were attending the 2016 Annual General Meeting of the Institute of Fire Engineers. The timescale for such a test method deemed by 57% of the respondents to be at the building completion, or before occupation, or once commissioning was complete but before the building was transferred to the occupiers. Frequency of testing was mentioned as after any major building or material alteration by 25% respondents where as 19% of respondents suggested testing should be carried out every five years.

6. Discussion

The questionnaire study was conducted to investigate the perception of Fire and Rescue professionals in Wales towards the effectiveness of passive fire protection measures (compartmentation and fire barriers) in buildings to prevent smoke and fire spread within stipulated time frames such as 30 or 60 minutes as set out in Approved Document B. It was revealed that all participants agreed that defects in building compartmentation can lead to fire/smoke spread problems and building compartmentation or fire stoppings can fail prematurely before 30 minutes. This perception was in line with the findings of Littlewood and Smallwood [9, 10] during in-construction testing of case study buildings, in which compartmentation appeared to have failed in less than five minutes. The main findings of the results presented in this paper are given below:

- Smoke gases were considered relatively more dangerous to occupant safety in the case of fire in buildings.
- 50% of respondents think that fire/smoke is not confined in building compartment for the time frames (30 or 60 minutes) prescribed in Approved Document B of the UK Building Regulations.
- All participants think that building compartmentation or fire stoppings can fail before minimum time frames.
- All participants agreed that defects in building compartmentation can cause problems in fire/smoke spread.
- 75% of the respondents find it difficult to assess the effectiveness of compartmentation during fire risk assessments, increasing to 88% in fire risk audits.
- 25% of respondents never inspect fire and smoke barriers in concealed spaces, while 63% rely on limited non-intrusive visual inspection alone to inspect the concealed spaces.

The results of the survey also revealed that most of the respondents referred to visual, non-physical and non-intrusive methods in context to the inspection of building compartmentation. This visual approach is not adequate for assuring the in-built performance of fire safety measures. Indeed, many of the defects that have been widely published as part of the UK's Building Performance Evaluation programme [31] and affect thermal performance, the authors believe could also affect fire performance [5]. Participants agreed that a mandatory non-intrusive and non-destructive test method for assessing that passive fire protection measures works in practice, in that smoke, fire and toxic gas is prevented from spreading from compartments before 30 or 60 minutes to comply with Approved Document B [19] and becomes mandatory. Such a test can be part of building risk assessment, risk audit or adopted in the Building Regulations to verify the effectiveness of fire safety measures and compartmentation. This will help in overcoming the difficulties in assessing the effectiveness of fire safety measures especially in concealed spaces, which was agreed by the majority of the respondents when fire risk assessments and fire risk audits are undertaken. These findings suggest that the building fire performance protocol that Cardiff Metropolitan University has been developing for testing, measuring and reporting is warranted, and some of the findings from the use of the first prototype from research and consultancy projects undertaken by the first author are discussed in these publications [9, 10]. The results presented in this paper form a preliminary study and thus only covered a limited number of Fire and Rescue professionals in South Wales, UK. The next steps in this research project until August 2017 are to conduct workshops with three of the 42 UK Fire and Rescue Service organisations in Llantrisant (the Headquarters of the South Wales fire and rescue service), and also in Manchester and London, to compare the findings with the results presented in this paper. Thereafter, to seek additional funding to target the 39 remaining UK Fire and Rescue Service organisations in a 12 month study. Furthermore, the authors will be trialing their fire performance test, measurement and reporting procedure on a number of dwellings under construction in South Wales, UK until August 2017.

7. Conclusion

Defects in the construction of compartmentation are one of the reasons for a 'Performance Gap' between the as designed and the as-built constructed buildings effecting thermal and acoustic performance. Recently, it has been shown by Littlewood et al. [5] that this performance gap also exists in fire performance of buildings and the authors have named this the 'Safety Gap'. The presence of construction defects that affect passive fire protection measures is mainly due to incorrectly fixed and missing fire barriers in and across construction components, errors in workmanship and construction site practices, inappropriate materials/components for passive fire-protection, short term fixes or improvisations, poor installation of fabric components and damage to components during maintenance. Building control (new buildings) or fire and rescue authorities (existing buildings) are not always able to thoroughly check the installed performance of in built fire safety measures, and the assurance of achieving relevant regulation or standards is unknown. In the survey discussed and presented of members of the Welsh branch of the Institute of Fire Engineers at their 2016 annual general meeting, the majority of professionals described that it is difficult to assess the effectiveness of the compartmentation. This is not only due to limited resource but also a lack of such a test method which can reduce the destructive, disruptive and expensive nature of carrying out defect inspection. Participants agreed that a non-intrusive and non-destructive test method can help in ascertaining integrity of building compartmentation and in-built performance of fire safety measures. These findings suggest fire industry support for Cardiff Metropolitan University's fire performance testing (active and passive protection measures) measurement and reporting protocol for buildings under construction and also those already built. This research work will be extended in terms of conducting further workshops with three fire and rescue service organisations in England and Wales, in addition to seeking further funding to expand the research across the UK, and implementing the protocol on new case study buildings under construction in Wales.

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