

Exploring the application of property flood resilience (PFR) measures for commercial buildings

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Key Points

- Previous researches on Property Flood Resilience (PFR) measures mainly focus on residential buildings.
- Commercial properties have significant importance to the economy.
- Flood impacts on commercial properties in different forms: direct and indirect; tangible and intangible.
- Commercial properties have different needs and requirements for PFR measures.
- This research uses mixed methodology through literature review, online questionnaire survey and case study.
- A relatively high level of awareness of PFR approaches and interventions is identified.
- The protection and resistant measures tend to be easier and less costly to implement.
- The resilience measures are often more permanent in nature and are more effective in the long term.
- Businesses can choose a bespoke package of measures for sufficient and effective protection from flooding.
- PFR measures can not only reduce the damages from flooding, but also enhance the reputation of the businesses and increase the value of the properties.
- Many businesses lack sufficient knowledge on PFR measures and have to rely on their own instincts or follow other people's practice.
- Flood resilience should be part of an organisation's business risk management strategy and incorporated into its operational management.
- Businesses need to assess their flood risks and implement specific PFR measures to address their own needs.
- RICS members and other relevant professionals can take an active role in the provision of the professional advice in flood risk assessment and PFR measures.
- Further research on the costs and benefits of different PFR measures has the potential to facilitate and encourage the uptake of more PFR measures in commercial properties.
- A 'one stop' hub for PFR measures is needed to provide the information needed for businesses.
- PFR measures should be incorporated in the building design and construction to avoid the costly retrofit in the future.

Executive summary

Commercial properties are a central component of national assets and Gross Domestic Product (GDP) and therefore their value is of broad significance to not only property owners but also local and national economic prosperity. Consequently, commercial property plays a significant role in the UK economy. For example, according to a Property Data Report in 2013, in the UK, the market value of the core commercial properties such as the retail, office, hotel and industrial properties was £683 billion. Commercial property also represents a major investment asset for both the pensions and insurance industries. Within the UK, the commercial property sector forms a significant portion of the economy with an estimated turnover of £3200 billion and employing about 22.8 million people with an average growth rate of 2.2% since 2008.

While commercial property investment may seem out-of-the-way for many people, its relevance is seen in the way rental income from business leases on offices, shops, industrial and leisure facilities supports pensions, insurance policies and savings plans. Therefore, the security of these investments is paramount to the large number of shareholders and stakeholders who count on them for pensions, insurance and investment plans.

Flooding can have a huge impact on commercial property and in hampering this security. Despite the huge investment in defences and engineering schemes, flooding remains one of the greatest threats to buildings, businesses and the wellbeing of humans. In recent years, UK flood risk management policy has recognised the need that flood cannot be totally prevented and therefore has embraced a proactive and more robust approach of managing flood risk and living with floods which is captured under the 'living with water' philosophy. This approach, in the context of property level flood risk, often entails building resilience into the system that is exposed to the risk. For residential properties, much attention has been focused towards the development and adaptation to the risk of flooding. This concept is commonly referred to as property level flood resilience or simply, property flood resilience (PFR) and has, since its inception, gained wider recognition in the domain of flood risk management. However, most studies relating to flood risk effect on properties or PFR have concentrated almost exclusively on residential properties.

Given that commercial properties tend to have many different characteristics, for example in form, materials and technologies used, there has up to now been scant research on the application of PFR to commercial property. Hence, the aim of this study is to explore the application of PFR towards this important component of the building stock and to develop some clear conclusions and recommendations for taking this approach forward.

The research adopted a mixed methods approach, commencing with a review of the existing evidence found in the literature encompassing government reports, policy papers, grey literature and published research. These findings were then used to inform the design of an online questionnaire survey of commercial property owners and tenants exposed to flood

risk. The results from the survey were used to inform the design of a detailed case study phase in which six examples of flood affected commercial properties were investigated in detail, comprising interviews with occupiers and owners, site visits and observations and scrutiny of documentation.

The findings revealed that loss and damage from the flooding of commercial properties is evident globally and seen to be prevalent in the UK. Damage caused is greatly associated with the continuous interaction between the natural and human systems and has been classified as either direct tangible, direct intangible, indirect tangible, or indirect intangible damage. The direct impacts entail physical damage to buildings and stock, while indirect impacts involve business disruption, lack of access and loss of business which are referred as secondary effects of flooding. The tangible part of these impacts can be easily measured and claimed, like damage to building and loss of stock; while intangible impacts such as loss of reputation and issues with renewing insurance are difficult to measure and may have huge impact on a business in the long-run. Studies have suggested that the indirect impacts of flooding often exceed the costs of direct damage and claims for business interruption may dwarf claims against property insurance.

The survey results revealed a relatively high level of awareness of PFR approaches and interventions and revealed that many of the at-risk commercial property owners / occupiers had already taken steps to install at least some measures. For example, nearly 90% of the survey participants had signed up to receive the Environment Agency flood warning service and over 60% had raised the level of electrical sockets above the expected flood levels.

The case studies provided further and more detailed insights into the experience of commercial property owners / occupiers and their response to being flooded and revealed some contrasting findings. One manufacturing company that had experienced a number of severe flood events had taken significant steps to improve the resilience of their premises, installing a range of resilient interventions and developing a clear strategy for managing future flooding. This might be considered an exemplar of what individual commercial property owners might adopt in becoming more resilient to flooding.

Another interesting case was provided by a business centre, which had taken steps to become more resilient after been flooded in 2007 by installing flood gates, developing a clear communication plan for their tenants and ensuring their IT systems were well protected. It was suggested that the installation of these measures had actually improved the reputation of the business and there was anecdotal evidence to suggest this was providing a commercial advantage. A useful example in another case was the benefit of procuring professional advice to help with the design and selection of resilience measures. This theatre building was found to have a comprehensive range of measures installed including pumps, flood gates, overflow pipes and flood kits with instructions for employees to follow.

The conclusions drawn from this research are that PFR approaches are indeed very much appropriate and effective for commercial properties. Many examples of these measures were found in practice with property owners and occupiers clearly appreciative of their

benefits. Unsurprisingly for organisations of this nature, it was evident that cost was a major consideration for property owners and there had to be a strong business case to warrant investment. Low cost interventions were prevalent suggesting the need for further work to bring down the costs of products and make professional advice more readily available and affordable.

A number of recommendations are made towards helping to widen the application and possibly mainstreaming of PFR for commercial properties including further research around the cost-benefit analysis of installing PFR and the development of robust information and guidance for businesses. There is clearly scope for RICS members to take a more active role in the provision of this expertise and professional advice in what will be a growing market in the future.

Chapter 1 Introduction

Flooding is one of the most wide-reaching and frequently occurring natural hazards in the world with noticeable impacts across cultures and geographies. On average, flood affects about 70 million people each year (UNISDR, 2011). The impacts include physical damage to properties, critical infrastructures and assets. The losses caused as a result of business interruption and general disruption to communities is significant (Jha et al., 2012). Also, the impacts on health are extensive and substantial, ranging from loss of lives and injuries sustained from the shock caused by the event, to the infectious diseases and mental health problems, including both acute and long-term issues.

The impacts of flooding in the UK have been far-reaching with over 5.2 million properties (around one in seven homes and businesses) exposed to some form of flood risk (Environment Agency, 2014). Estimates suggest that over £220 billion worth of property is potentially at risk of flooding in England and Wales, from different sources of flooding such as coastal, river, surface water, ground water and sewer flooding (Kenney et al., 2006). Flood risk is projected to increase across the UK with annual damages expected to increase from a current reference point of £1 billion to somewhere between £1.8 and £5.6 billion by the 2080s for England.

As a means of mitigating these impacts, various innovative approaches to protecting property have been developed (Oladokun et al., 2017). For example, structural measures are engineered solutions designed with defined limits of disturbance (Proverbs and Lamond, 2017). These structural measures offers some amount of resilience to flooding, it is however very difficult to sustain and many will be overwhelmed by the next greater flood event. Despite the huge investment in structural approaches and engineering measures, flooding remains one of the greatest threats to buildings, businesses and the wellbeing of humans. In recent years, UK flood risk management policy has recognised the need that flood cannot be totally prevented and therefore has embraced a proactive and more robust approach of managing flood risk and living with floods which is captured under the 'living with water' philosophy (DEFRA, 2005). This approach, in the context of property level flood risk, often entails building resilience into the system that is exposed to the risk. This concept is commonly referred to as property level flood resilience or simply, property flood resilience (PFR) and has, since its inception, gained wider recognition in the domain of flood risk management (Oladokun et al., 2017 and Kelly et al., 2019).

However, most studies relating to flood risk effect on properties or PFR have concentrated almost exclusively on residential properties. Not much has been written on the application of PFR to commercial property (Pottinger and Tanton, 2011). Commercial properties tend to have many different characteristics, for example in form and technologies used, so this research seeks to explore the application of PFR measures towards this important component of the building stock.

Chapter 2 Aim and objectives

This research aims to investigate the application of property flood resilience (PFR) measures to commercial properties.

In order to achieve this aim, several objectives were set:

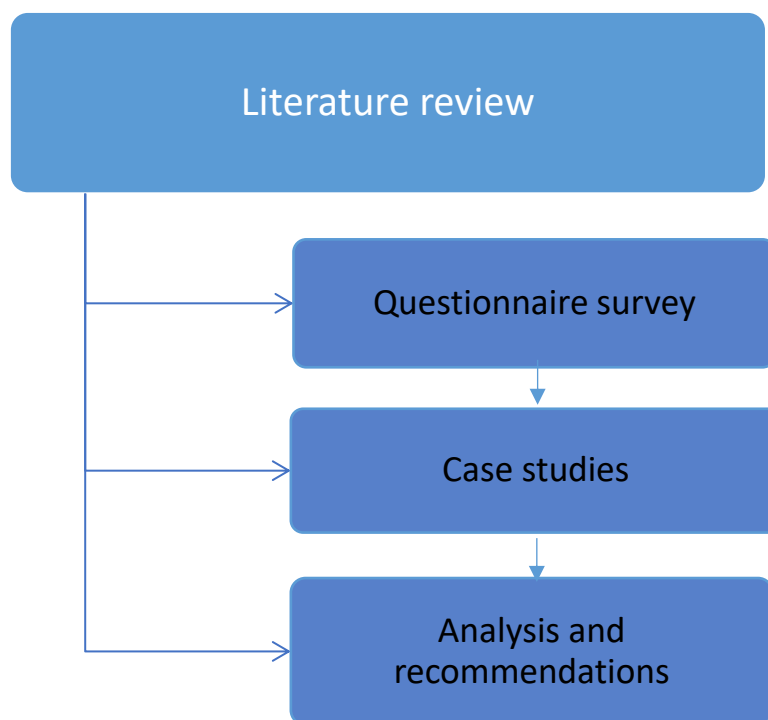
- To review the impacts of flooding on commercial properties, the businesses and the occupants;
- To review the existing PFR measures on commercial properties;
- To conduct a survey of commercial property occupants affected by flooding on their awareness of and the implementation of PFR measures;
- To conduct detailed case studies of commercial properties to elicit good practice in PFR measures;
- To analyse, interpret and consider the findings from the review of the literature and empirical evidence;
- To draw conclusions and recommend how commercial property occupiers and owners can improve the resilience of their premises to flooding through the application of PFR.

Chapter 3 Research methods

3.1 Research process

In order to achieve the aim and objectives of this research, a mixed methodology was adopted in this research. The research started with a desk-based literature review to assess the existing knowledge in the research area. A questionnaire was developed based on the knowledge from the literature review, and a questionnaire survey was conducted among commercial property occupants who have been affected by flooding in the past. Findings of the questionnaire survey informed the design of a series of case studies. The primary evidence from both the questionnaire survey and case studies were analysed to draw conclusions and produce the recommendations for the commercial property occupants to improve their property flood resilience. The research process is shown in Figure 1.

Figure 1 Research Process



3.2 Study area

Based on the scope of the research, York, Sheffield and Worcester were selected as the main study areas for the questionnaire survey. These areas are historically flood prone and have experienced a series of flood events in recent years. For example, in 2019, River Don

broke its banks in several places in and around Sheffield. In February 2020, Storm Ciara caused flooding in York and Storm Dennis left large parts of Worcester underwater.

3.3 Literature review

Existing literature sources were reviewed to identify and assess the extant knowledge related to the focus of this research, and this clarified the scope and direction of the study, within the aim and objectives set. The literature review firstly looked at the impacts of flood on the commercial properties, the businesses and the occupants. The available property level flood risk mitigation measures were then investigated to assess their suitability and effectiveness for commercial properties. This review process informed the questionnaire survey design and the case study protocol.

3.4 Questionnaire survey

To elicit the perceptions and attitudes of commercial property owners towards flood risk and explore their views on the application and effectiveness of PFR measures, a questionnaire survey was conducted. A questionnaire survey was chosen because it is the most efficient way of reaching a large audience and its standardised format can generate comparable data (Brace, 2018). It allows participants to complete the questionnaire at their own convenience and comfort without the researcher being present, thus eliminating investigator bias and social desirability bias and increasing objectivity and internal validity of the research (Fricker and Schonlau, 2002). The questionnaire consists of four sections: 1) the general information about the business and property; 2) the flooding experience and its impact on business; 3) awareness of PFR measures and their effectiveness; 4) further comments on flooding and PFR measures.

3.5 Case studies

In order to get more detailed insights into the flooding experience of commercial property owners, their flood risk resilience practices, and to allow the findings from the questionnaire survey to be triangulated, a series of case studies were conducted. Case study is a research into a particular place, event or community which collects information using a variety of approaches. It allows detailed descriptions of particular instances of a phenomenon that are commonly based on different data sources (Yin, 2011). In this research, research tools of interview, site visit and documentation were used for qualitative data collection. This provided an opportunity to explore the key issues identified from the survey and to develop more detailed understanding of the challenges and opportunities in the context of flood resilience measures in commercial properties.

Chapter 4 Flood impacts on commercial properties

4.1 Commercial property

Commercial properties are a central component of national assets and Gross Domestic Product (GDP) and therefore their value is of broad significance to not only the property owners but also local and national economic prosperity. Consequently, commercial property plays a significant role in the UK economy (Bhattacharya-Mis and Lamond, 2016). For example, according to a Property Data Report in 2013, in the UK, the market value of the core commercial properties, such as the retail, office, hotel and industrial properties was £683 billion (British Property Foundation, 2014). Commercial property also represents a major investment asset for both the pensions and insurance industries (Investment Management Association, 2010). In 2010, funds held around 4.8% (or £98bn) of their investments in direct property. Within the UK, the commercial property sector forms a significant portion of the economy with an estimated turnover of £3200 billion and employing about 22.8 million people with an average growth rate of 2.2% since 2008 (BIS, 2010).

While commercial property investment may seem out-of-the-way for many people, its relevance is seen in the way rental income from business leases on offices, shops, industrial and leisure facilities supports pensions, insurance policies and savings plans (Pottinger and Tanton, 2011). Therefore, the security of these investments is paramount to the large number of shareholders and stakeholders who count on them for pensions, insurance and investment plans. Flooding can have a huge impact in hampering this security.

4.2 Flood risks to commercial property

It is estimated that around 185,000 commercial properties are at a direct risk of being affected by flooding (Environment Agency, 2009). The coastal profile, areas within 10km of the coast, is occupied by around 10 million people and accounts for 40% of the manufacturing industry (Kenney et al., 2006). Coastal flood risk is growing with climate change (Haigh, et al., 2020). Businesses located or operating in these areas are likely to face an additional risk of losing coastal business locations or access to assets and facilities because of coastal flooding (Climate Change Committee, 2016). In addition, surface water flooding and flash flooding in urban areas means that buildings and businesses located away from flood plains and coastal areas may also be exposed to flooding.

According to EKOS Consulting Ltd (2008), some of the impacts experienced by businesses during the summer floods of 2007 in Yorkshire are damaged or lost stock and equipment, damage to buildings/premises, inability to conduct business, and inconvenience to staff. The statistics on the 2007 floods laid emphasis on the havoc flooding can wreck on business: with records showing around 8,000 businesses were affected, resulting into 35,000 insurance claims, averaging between £75,000 and £112,000 (Pottinger and Tanton, 2011). In the 2013-14 winter flood event, around £446 million was paid out by the insurance industry as business claims (ABI, 2014). These huge sums indicate the importance of helping businesses to become more resilient and highlight the need for further research to inform practice and future policy development (Pottinger and Tanton, 2011).

Loss and damage from the flooding of commercial properties is evident globally and seen to be prevalent in the UK (Lamond et al., 2017). Damage caused is greatly associated with the continuous interaction between the natural and human systems (Bhattacharya, 2014). Flood damages, whether potential or actual, have been classified as either direct tangible, direct intangible, indirect tangible, or indirect intangible damage (Merz et al., 2010), as summarised in Table 1.

Table 1 Classification of flood impacts on commercial properties (Merz et al., 2010)

Flood impact	Tangible	Intangible
Direct	<ul style="list-style-type: none"> • Structural damage • Damage to furniture and fittings • Loss of stock • Damage to equipment and machinery 	<ul style="list-style-type: none"> • Loss of document • Ill-health
Indirect	<ul style="list-style-type: none"> • Loss of production • Cost of evacuation of goods and staff • Clearing and cleaning up cost • Repair cost 	<ul style="list-style-type: none"> • Loss of reputation • Business disruption • Issues with renewing insurance

The direct impacts entail physical damage to buildings and stock, while indirect impacts involve business disruption, lack of access and loss of business which are referred as secondary effects of flooding (Lamond et al., 2017). The tangible part of these impacts can be easily measured and claimed, like damage to building and loss of stock; while intangible impacts such as loss of reputation and issues with renewing insurance are difficult to measure and may have huge impact on a business in the long-run (Lamond et al., 2017). Studies have suggested that the indirect impacts of flooding often exceed the costs of direct damage and claims for business interruption may dwarf claims against property insurance (Kleindorfer and Germaine, 2005; Heite et al., 2009).

4.3 Direct flood damage to commercial property

The damage caused as a result of direct contact with flooding relates to physical damage to business assets during a flood event. This includes damage to infrastructures, fittings and

furniture, machineries, equipment and loss of stocks due to lack of mobility (Tierney, 1997; Zhang et al, 2009). Typically, enterprises with large fixed assets like buildings and huge inventories from raw materials to finished products are more susceptible to direct physical damage. According to Chang and Falit-Baiamonte (2002), when businesses suffer from this form of damage, it can be directly linked with the total loss suffered by business.

The direct tangible impact relates to the potential cost of damage, which can be estimated such as the value of physical structures or economic assets exposed to loss, while loss of business records could be classified as direct intangible impact alongside resultant ill-health of staff. However, properties with higher dealings in cash and soft business securities are safer in terms of physical vulnerability since they are intangible in nature and can be safely stored in separate locations (Zhang et al., 2009). Lost documents and records are vital physical losses and often considered intangible impacts, which can delay post event recovery work.

4.4 Indirect impacts to commercial property

Indirect damage is induced by flooding, but occurs, in space or time, outside the actual event (Thieken et al., 2008). Indirect losses usually result as a consequence of direct losses. The damage caused as a result of indirect contact with flooding may affect the continuity and performance of business and thereby incur loss by taking time to recover from its disrupted state of operation (Alesch et al, 1998; Tierney, 2007; Parker, 2009). Therefore, even if a business escapes direct damage it may be forced to shut down as a result of indirect impacts such as disruption in supply chain, access problems for employers and employees, loss of customers and so on (Tierney, 2007). All expenses for disaster response, such as costs for sandbagging, evacuation and emergency services, are classified as indirect tangible damages. The cost of clearing and cleaning up and unavailability of staff (e.g. due to injuries sustained during flood event) are regarded as indirect intangible costs which can be substantial (Thieken et al., 2008).

One component that can be affected by both the direct and indirect impacts is the value of commercial property. According to the RICS (2011), the value is directly impacted through the physical impacts of flooding on the physical assets, while the indirect impacts are based on the social, economic and political assumptions associated with the condition of the asset at risk.

Chapter 5 Property level flood risk mitigation

Whilst knowledge about the disruption and the damages caused to businesses is increasing, there is still relatively little evidence of the actions from most businesses to minimise such damages and ensure they are prepared against future risks (ASC, 2016). The little evidence available is often subjective in nature and mostly concerning small and medium enterprises (ASC, 2016). While traditional flood defences may be available to provide protection against coastal and river flooding for large communities, there will always be some commercial properties that would not benefit from such schemes. Such defences are not likely to deal properly with localised pluvial, surface water or groundwater flooding. Furthermore, there will always be a residual risk, as flooding cannot be totally prevented even after flood management schemes have been put in place.

The Department for Communities and Local Government (2007) highlights some of the causes of this residual risk as: failure of flood management infrastructure such as a breach of a raised flood defence; blockage of a surface water sewer or failure of a pumped drainage system; a severe flood which causes a flood defence to be overtopped; and floods outside the known flood risk areas. In these cases, business owners need to have a range of protection or resilience measures they can incorporate into their properties to take care of this flood risk (Tagg et al., 2016). According to the Environment Agency, most businesses can save up to 90% on the cost of lost stock and moveable equipment by taking action to prepare in advance of flooding. Also, by preparing for flooding, they can significantly reduce financial losses; limit damage to property, stock and equipment; minimise business disruption and continuity, help to retain clients and contracts; maintain customer, supplier and business records; and obtain insurance cover (Dhonau and Rose, 2016).

In terms of protection of properties, a hierarchy of options has been recognised which is associated with decreasing residual flood risk, although this depends on the flood type and building being considered (Department for Communities and Local Government, 2007).

These are summarised as follows:

- 1) **Avoidance:** comprises of a range of measures including location of buildings in areas of least risk (land use planning), raising properties above the flood level, use of bunds or other hard defences to keep floodwater away.
- 2) **Resistance:** comprises of measures that are taken to prevent floodwater from entering into the building and damaging its fabric and contents.
- 3) **Resilience:** entails sustainable measures that can be integrated into the building fabric, fixtures and fittings in order to lessen the potential of damage caused by floodwater. These measures would allow for quicker drying and easier cleaning,

and also ensure that the structural integrity of the building is not compromised thereby reducing the recovery time for the building to be re-occupied.

- 4) **Reparability:** forms a subset of resilience, covering design of elements that facilitate replacement and repair such as sacrificial finishes.

Although property level flood risk mitigation has to a very large extent focused on residential buildings, many of the measures adopted in protecting residential properties can be applied to commercial properties. These include those designed to keep water at bay to those required to minimise floodwater impacts (both direct and indirect) when water enters the property. These measures have been classified into two main categories, the resistance measures (also called dry proofing measures or water exclusion strategy) and the resilience measures (also referred to as wet proofing measures or water entry strategy). Table 2 shows the measures adopted in commercial properties under these two categories.

Table 2 Categorisation of adaptation measures employed in commercial properties

	Adaptation Measures	Resistance	Resilience
1	raised electric sockets and wirings		√
2	equipment and machinery on raised plinth		√
3	record back up (for customers, suppliers and staff)		√
4	number of storey		√
5	emergency flood plan		√
6	airbrick	√	
7	flood guards for door and window	√	
8	sandbags	√	
9	vent covers	√	
10	toilet seal pans	√	
11	raised doors and windows	√	
12	sump and pump systems		√
13	backup power source		√
14	non-return valve on drains and pipes	√	
15	water resistant paint	√	
16	flood insurance		√
17	first aid kit		√
18	elevators equipped with water sensor		√
19	electrical panel with WIFI enabled breakers		√

5.1 Resistance measures

The purpose of applying these kinds of measures to a commercial property is to make it watertight to floods of limited duration (a few hours) and depth (typically less than 600mm) (Department for Communities and Local Government, 2007). Consequently, this approach is often adopted up to a threshold value of 600mm around a property, although in some cases surveyors may recommend this to be conducted up to 300mm (ODPM, 2003). This will help to reduce damage to the internal fabric of the building and its contents such as stocks,

equipment and machinery, staff, customers and suppliers records, thus reducing the associated stress and suffering to business users and owners.

These measures provide property owners the opportunity to relocate important items to a safer level. To achieve this, the resistance approach is focused on keeping floodwater out of a building by sealing all water entry paths. It is essential that all potential entry points of floodwater are identified and protected. Any openings left unsealed serve as a passage for floodwater to enter the building, meaning that the resistance approach fails. Work has been done to identify these potential points of water entry mainly in residential building (CIRIA and Environment Agency, 2003; ODPM, 2003) and some of these findings can also be applied to commercial properties with similar features. In an ideal case, floodwater would be fully kept out of the buildings; however, this may expose the building to structural risks as a result of the weight of water against walls.

Therefore, in order to adopt this kind of measure, it is essential to consider and ensure that the building structure has the capacity to resist four types of flood-related forces: (1) hydrostatic flood force that freestanding water exerts on a submerged object; (2) buoyancy force that a building receives from surrounding floodwaters; (3) hydrodynamic force that vertical surfaces receive from moving floodwaters; and (4) debris impact force to withstand the flood-borne debris strikes on the side of building (World Meteorological Organization, 2012). The advantage of applying resistance is that the building is kept dry and the contents (stock and valuable records) inside the building are not affected by flood (TUHH, 2010). However, one of the disadvantages is that the stability of the building structure can be jeopardized because of the heavier load of floodwater (World Meteorological Organization, 2012).

The products that make up the resistance measures include both flood protection products (such as floodgates, door and window guards for doorways and low level windows), the installation of non-return valves on sewers to prevent backflow, barriers and flood doors that cover apertures and the use of resistant materials (such as engineering bricks, cladding systems, plastic skirts, flood-resistant doors, and wall coatings to limit water ingress) (Tagg et al., 2016). However, it is recommended that above the 600mm threshold height, a resilience approach should be adopted (Department for Communities and Local Government, 2007).

5.2 Resilience measures

A flood resilience approach involves taking measures to ensure a business can recover from the impact of a flood quickly, by minimising disruption and allowing business continuity or resumption as soon as possible. According to the Department for Communities and Local Government (2007), the use of appropriate resilience measures through careful selection of building materials, construction techniques and internal finishes can help reduce the risk of flood damage to the business premise and the integral components inside the building. In terms of the building materials, these must possess properties that are resistant to flood

forces, including deterioration caused by repeated inundation and excessive moisture and humidity during and after flooding (World Meteorological Organization, 2012). Also, because flood water may travel with sediment, chemicals and organic materials, which can be harmful to the structure and the occupants, the structure (both floor and wall) should be covered with materials that can be easily cleaned without leaving any contaminants behind (World Meteorological Organization, 2012). Concrete, hard brick, plastic, metal, and pressure-treated wood have been identified as suitable materials for this purpose.

Meanwhile, there are variety of techniques that should be applied in order to minimise the damage caused to the building and its contents. One of these is to ensure that the building has flood vents or permanent openings that allow water to flow in and out of the structure without damaging the foundation (CIRIA and Environment Agency, 2003). Other measures that are vital to enabling quick recovery are to ensure that mechanical and utility facilities (such as electrical, heating, ventilation, plumbing, and air conditioning equipment) are raised above the expected flood level (ODPM, 2003). Vulnerable items, such as utilities, appliances, computers and contents, are relocated, permanently or temporarily, to higher parts of the building or placed above the expected flood level. Furthermore, by making changes to the location of services and electrical points such as raising plug sockets up the wall, business owners will not only improve the safety of the building for the occupants, but can also save significant amounts of money on repairing these after a flood (Dhonau and Rose, 2016).

According to Dhonau and Rose (2016), the following measures should be considered in making a commercial property resilient:

- 1) raising electrical sockets, electrical wiring and controls for ventilation systems
- 2) raising equipment and machinery on plinths
- 3) using materials that can withstand flooding, for floors and the lower part of walls and staircases.
- 4) backing up customers' data on a regular basis.
- 5) storing customers' files and supplier contracts safely.
- 6) keeping insurance policy in a secure, accessible place, as well as a copy in a 'Grab bag' or 'Battle box'.
- 7) ensuring drains from your premises are running efficiently

Other measures identified are retrofits such as equipping elevators with water sensors to prevent them from proceeding to flood-inundated building levels and also equipping electrical panels with WIFI enabled breakers to allow for remote shut off (Moudrak and Feltmate, 2019).

Currently, there is no regulation and accepted standards around the specification and deployment of these PFR measures which thereby limits its potential impacts. However, with the launch of the property flood resilience Code of Practice by the Construction Industry Research and Information Association (CIRIA), more attention is being directed towards the property level flood risk mitigation. The Code of Practice (CoP) is concerned with PFR measures that can be introduced to buildings at risk from flooding (Kelly, et al.,

2019). The CoP comprises of six standards with the purpose of providing benchmark for good practice and also to encourage consistency and efficiency in the implementation of PFR.

Chapter 6 Research findings

In this section, the results from the questionnaire survey are presented and analysed. Following this, the flood resilience practices from six different case studies are also introduced in order to provide some useful insights into the current PFR practices and experiences.

6.1 Results from the questionnaire survey

As this phase of the research coincided with the UK national lockdown from the Covid-19 pandemic (August 2019 to May 2021), it was decided to conduct an online questionnaire survey. 450 survey invitations were sent to a sample of purposively selected businesses in the identified areas by email. A disappointing total of 25 responses were received, representing a response rate of 5.6%. The low response rate was not surprising because during the research period many businesses had to close down or furlough the majority of their staff. However, the questionnaire survey still provides a useful snapshot of the current situation of commercial property flood resilience practice as indicated in the following results.

Demographics

Among the 25 responses, 60% of the respondents owned their property and 40% were tenants. Their business types vary from office (17%), retail (12.5%), hotel (12.5%), industrial (4%) and others (54%). Over a third of the properties were valued up to £250,000.00, and about a fifth of them were valued at £750,000.00 - £1 million. The majority (87%) had fewer than 20 employees, and two thirds of them had an annual turnover of up to £250,000.00. This shows the participants are mainly SMEs. Please refer to Figures 1, 2 and 3.

Figure 1 Business type in the survey

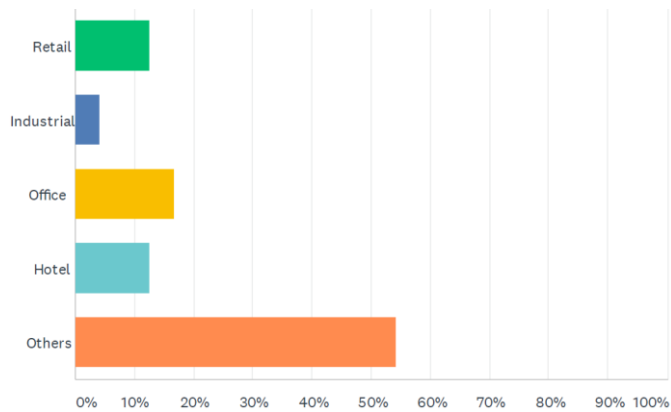


Figure 2 Value of the properties

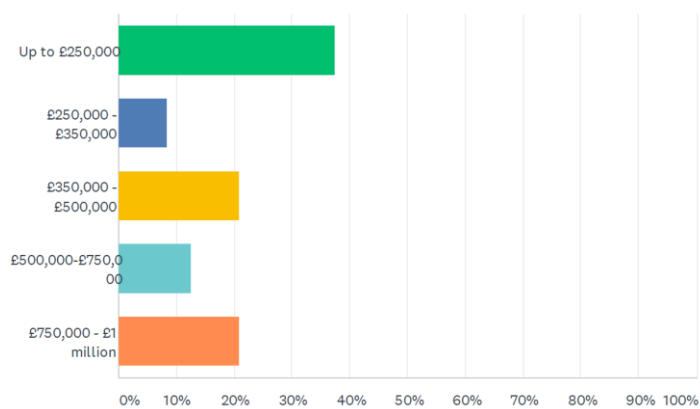
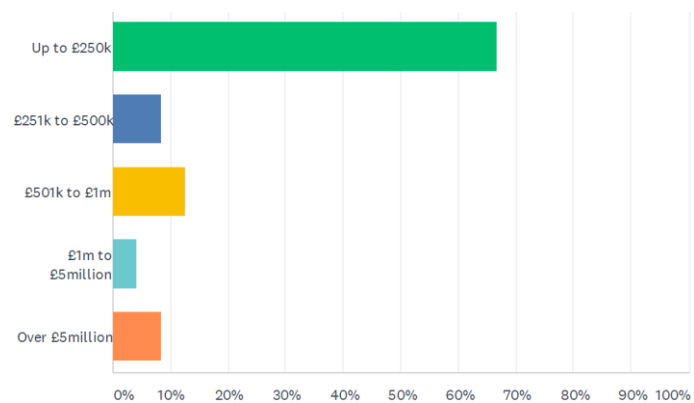


Figure 3 Business annual turnover



70% of the properties were two storeys, and the rest were either one storey or 3 storeys. Half of the participants had been in their current properties for over 10 years and about two fifth of had been in their current properties for less than 5 years, which shows the data set present both the long-term and short-term property occupants. The size of the surveyed properties were relatively evenly distributed (27% over 250m², 18% 201-250m², 9% 151-200m², 23% 101-150m² and 23% 50-100m²). See Figures 4, 5 and 6.

Figure 4 Number of the property storeys

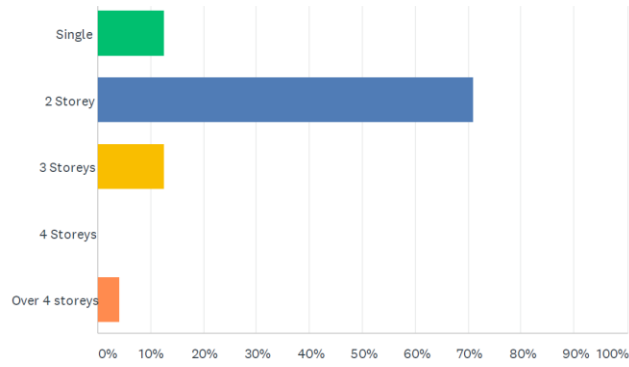


Figure 5 Size of the property

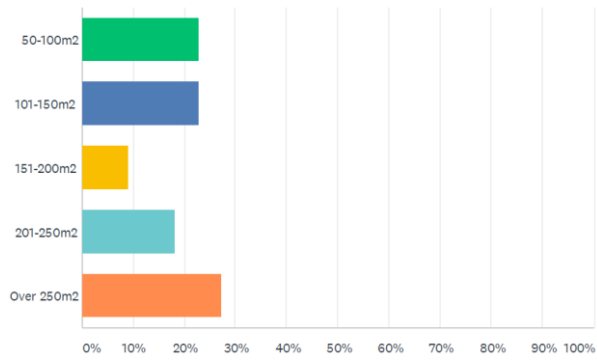
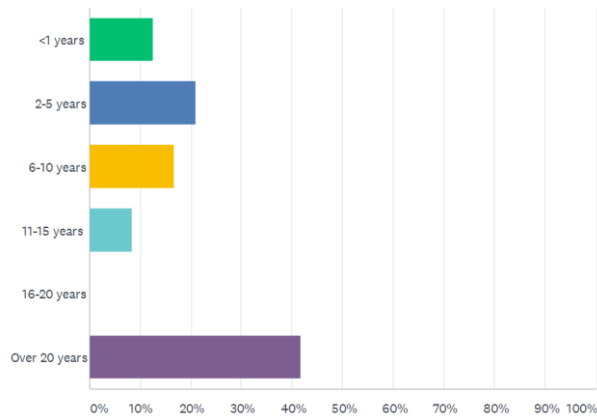


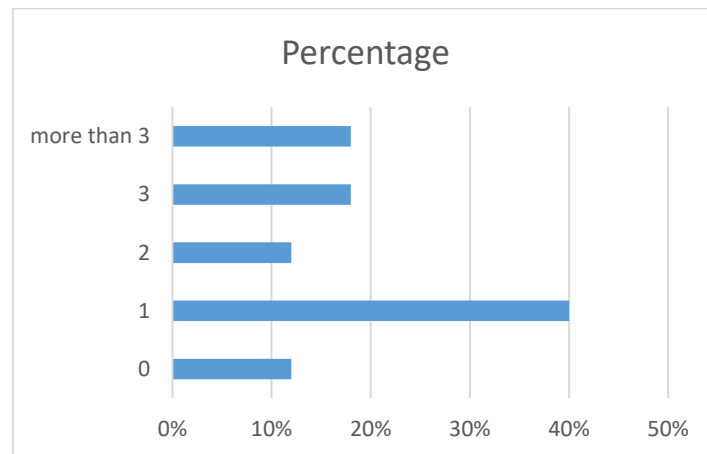
Figure 6 Years of occupation of the property



Flood experience

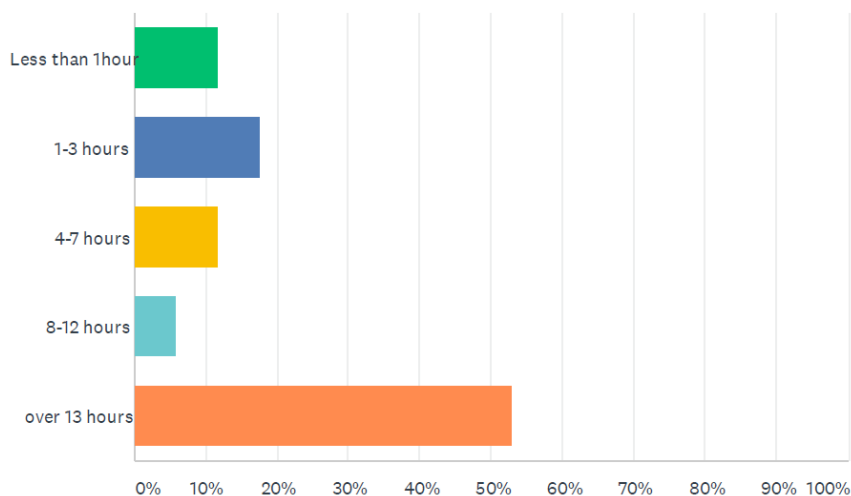
The majority of the participants had experienced flooding in their current properties. Two fifth of the properties had been flooded once, and about half of the properties had been flooded multiple times (3-12 times) (see Figure 7). Less than a fifth of the participants had moved their business to a temporary location while their properties were being repaired after the flooding.

Figure 7 Times the properties have been flooded



It is very encouraging that the same proportion of the participants reported that they received the flood warning before their properties were flooded and over half of them received the flood warning 13 hours in advance, but almost 30% of them receive the warning less than 3 hours in advance (Figure 8). The vast majority of them reported that they would have time to move items above the expected flood level to reduce / minimise the flood damage.

Figure 8 Time between the flood warning and the flood water enter the property



Sixty percent of the participants reported either moderate or high impact on their staff from the flooding, but the impact on the supply chain is less severe with only a third of the participants reported either moderate or high impact (see Figures 9 and 10).

Figure 9 Impact on the staff from the flooding

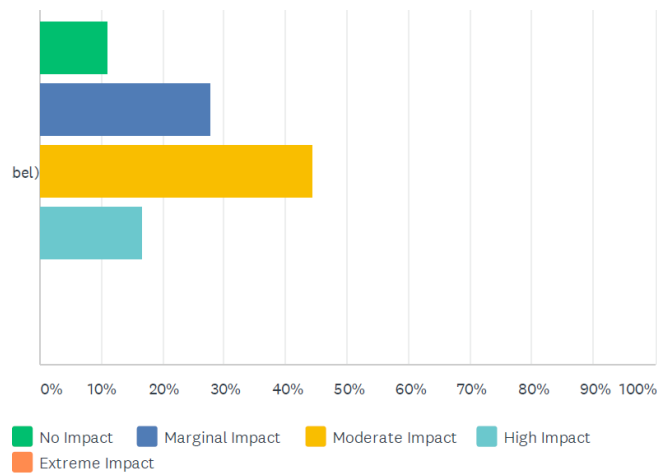
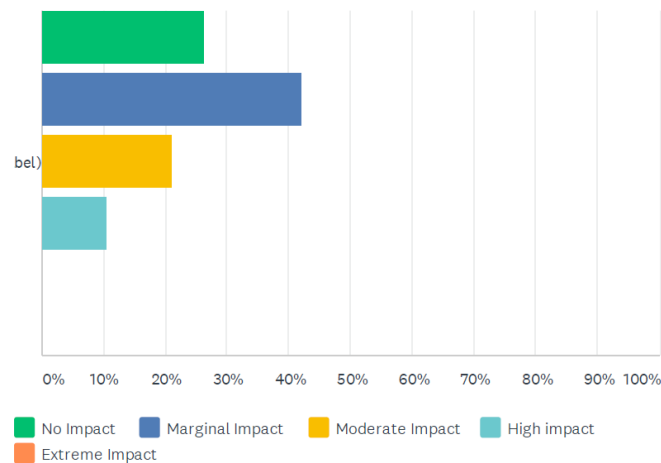


Figure 10 Impact on the supply chain

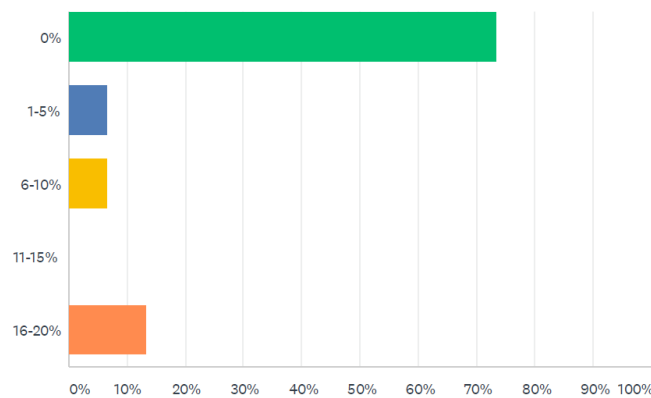


Seventy five percent of the participants did not experience any insurance premium increase after the flooding, and about 15% reported insurance premium increase of more than 15%.

Once the property was flooded, it took between 1 month to 18 months to complete the repair work, with an average of 5 months. The damage caused by the flood ranged from £100.00 to £250,000.00, with an average of £38,850.00.

Only half of the businesses surveyed had an emergency flood plan in place.

Figure 11 Insurance premium increase after flooding



Flood protection measures

In this section, participants were asked to indicate their awareness of the flood protection measures (1 means 'not aware', and 5 means 'fully conversant', and 2, 3 and 4 in between) and whether they had implemented any particular measures. Table 3 is the summary of the mean of the awareness and the percentage of the implementation of flood protection measures from the survey.

Table 3 Awareness and implementation of flood protection measures

Protection Measures	Awareness	Implementation
Moving vulnerable items above expected flood level	4.857	71.43%
Keeping copies of customers' file in a safe place	4.833	46.15%
Raising equipment and Machinery on plinths	4.667	25%
Relocating more expensive items above the expected flood level	4.667	53.85%
Keeping copies of staff's file in a safe place	4.5	46.15%
Registering for flood warning	4.429	86.67%
Use of Sandbags to prevent water entering	4.384	35.71%
Safe storage of supplier contracts	4.333	45.45%
Moving stocks to another site	3.909	23.08%
Generators to power pumps and emergency lighting	3.167	8.33%
Sump and pump fitted	3.0	53.85%

Flood resistant measures

In this section, participants were asked to indicate their awareness of the flood risk resistant measures (1 means 'not aware', and 5 means 'fully conversant', and 2, 3 and 4 in between), and whether they had implemented any particular measures. Table 4 is the summary of the mean of the awareness and the percentage of the implementation of flood resistant measures from the survey.

Table 4 Awareness and implementation of flood resistant measures

Resistant Measures	Awareness	Implementation
Doors and windows guards to prevent water entering the property	4.083	46.15%
Manual Airbricks and Vents covers	3.545	38.46%
Raised windows	3.454	16.67%
Using water proofing membrane on external walls	3.333	7.69%
Waterproofing of external walls	3.077	0.00%
Installation of Flood doors and door guards	3.077	0.00%
Installation of non-return valve to prevent water coming through drains	2.846	0.00%
Smart airbricks and vents that close automatically	2.833	7.69%
Door and window guards that close automatically	2.385	0.00%

Flood resilience measures

In this section, participants were asked to indicate their awareness of the flood risk resilience measures (1 means 'not aware', and 5 means 'fully conversant', and 2, 3 and 4 in between), and whether they had implemented any particular measures. Table 3 is the summary of the mean of the awareness and the percentage of the implementation of flood resilience measures from the survey.

Table 3 Awareness and implementation of flood resilience measures

Resilience Measures	Awareness	Implementation
Raising electrical sockets above likely flood level	4.556	61.54%
Replace carpet floor finishing with floor tiles	4.444	53.85%
Installing concrete floor instead of timber floor	4.222	61.54%
Moving gas and electric meters above likely flood level	3.333	30.77%
Replacing normal plaster with water resistant plaster	3.182	25.00%
Installation of hardwood flooring	3.154	7.69%
Tanking of ground floor and basements	3.083	15.38%
Replacing kitchen units with stainless steel units	2.769	7.69%
Resin damp proof membrane beneath concrete floor, to prevent the water rising from underneath	2.455	15.38%
Installing steel staircase	2.364	16.67%
Replacing kitchen units with plastic units	2.333	7.69%
Use of marine ply for kitchen units / cabinets	2.273	15.38%
Installing concrete staircase	2.091	23.08%
Fixing plasterboard horizontally instead of vertical fixing	2.000	8.33%

6.2 Results from the case studies

In order to have a better understanding of the flood awareness and readiness of commercial properties, six case studies were conducted in this research. The participants were recruited from the questionnaire survey who expressed their willingness to participate, and they represented different types of commercial properties in the Midlands and the north of England, including a factory, an office building, a holiday rent, two sports clubs and a touring theatre company. The case studies were conducted between May to June 2021, and the data was collected through semi-structured interviews with the property owners / managers, site visits and documents (e.g. insurance records, newsletters and company manuals such as flood strategy / plan).

Case No 1: Manufacturing factory

Flood experience

This property is a specialist coating factory in an industrial estate in the Midlands with about 40 employees. The factory building is one storey only and is divided into different areas for production, storage, R&D lab, office and canteen. A small river passes by a few meters away from the factory. It was flooded before in 2007 (twice) and the latest flood was in 2018 when the river burst its bank due to heavy rains and the blockage down the stream. The flood caused damage of about £1 million in the form of raw materials, machinery and IT equipment, office and furniture, but excluding the cost of their own labour doing the cleaning and repairing, so the true cost could be well above £1 million. As the property is uninsurable due to its previous flood history, the money had to come from the company's own cash reserves, which had a very significant impact on the company. After the flood, although it only took the company 2 weeks back to production, it took about 9 months to get back to a state of normality.

After the previous floods in 2007, the company spent £50,000.00 to build a concrete wall down the river side to hold the water back. It did work in the past, but it failed to work in the 2018 flood. In fact, it may even have made the situation worse as it prevented the water to flow out later on. They installed CCTV camera to monitor the river and registered with the flood warning with the Environment Agency. But on this occasion, they only received the Flood Alert 4 hours in advance and the Flood Warning 2 hours in advance. To make things worse, it was a bank holiday weekend and no staff was on site, so they couldn't take much action to reduce the damage.

Flood strategy

After the 2018 flood, the company realised that flood risk is real to them and they have to learn to live with water, as commented by the operation manager:

"As a business, we need to consider how we protect as much of our business as possible, knowing that one day it is going to flood again and planning for the fact that that's the case, you have to balance the work that people do on a day

to day basis. We will be flooded in the future, but at least then, hopefully, we can recover quicker, and smarter.”

They appointed one manager responsible for incorporating the flood resilience into their business resilience strategy and operational management so they can prepare for future flood events and minimise the damage and interruption to production and customers. The operational manager confirmed:

“We do have a flood strategy. But actually it's not a flood strategy. It's a strategy against anything that could impact our business. Yeah, because we've suffered more than one type of incident, and a really good example is COVID when COVID hit last year. We treated COVID as an incident, the same as we'll treat flood as an incident. ... And when I think about what's happened during COVID, if we hadn't learned what we'd learned in the flood, I don't think we would have dealt with it in the same way.”

They also constantly review their flood strategy in order to address any new risks identified. As flood will impact on every aspect of the business, they encourage everyone in the company to propose any good ideas / practices to improve their flood resilience.

Resilience measures

During the 2018 flood, there was a huge amount of physical data loss that had been built up over the years. Now the company puts more emphasis on backing data up electronically so the intellectual property is better protected. This is a slow process as it is not easy to change people's behaviour and organisational culture. The company is a family-owned business and many people are multi-tasking, so flood resilience is rarely everyone's top priority.

The factory is on a slope, so they now park their forklift trucks, which are essential to the operation of the site, at the top of the site so they have a better chance of being operational after a flood event. Raw materials are now stored in barrels with watertight lids so they are protected from water and production can be resumed very quickly after flood. This will not only minimise the financial damage but also reduce the lead time.

After the flood, they change the carpet in the office to carpet tiles with rubber back (see Photo 1) so if it is flooded again, they can jet wash the carpet tiles, dry them and put them back quickly and easily. This has been tested twice now and proved to work well. They also changed the plaster board to a plastic alternative (see Photo 1.2) so that they can be cleaned down and put back (this is not been adopted in the offices due to the acoustic effect). In the kitchen, they bought stainless steel kitchen units (see Photo 3) and standalone tables (see Photo 4) which can be easily cleaned and put back to use after flooding.

Photo 1 Carpet tiles in the office

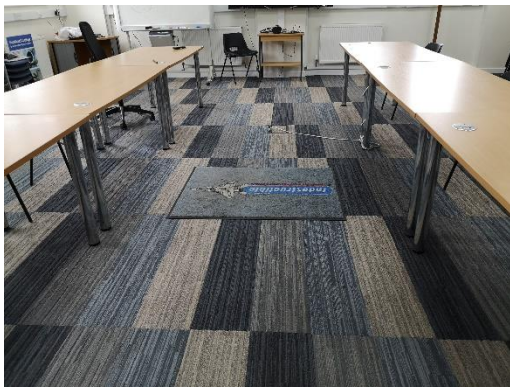


Photo 2 Plastic board on partition walls



Photo 3 Stainless steel kitchen units



Photo 4 Stand-alone tables in the kitchen



All electrical points have been raised over 1.2 metres (see Photo 5), and the associated cabling comes down from the ceiling. The computer screens are adjustable on a pole so they can move up in the event of flood (see Photo 6).

Photo 5 Raised electrical points



Photo 6 Cabling from the ceiling



All raw materials and important equipment are stored on shelves above 1.2 meters (e.g. forklift truck chargers in Photo 7 and servers in Photo 8) or on raised stands (see Photo 9 and 10), and only materials with a low value and/or for immediate use on the floor.

Photo 7 Forklift chargers on raised shelf



Photo 8 Servers on raised shelf



Photo 9 / 10 Equipment on raised stand



Local community and support

As the blockage in the river was a major cause of flooding, the company realised that they need to work closely with the local community and other relevant organisations such as the Environment Agency, local council, water company and the National Flood Forum. They now actively monitor the debris on the river and surrounding areas so they can report to the Environment Agency and the council to reduce flood risk to the local community.

They participate in the local flood forums but the local council's focus seems mainly on the residential properties and they pay little attention to the needs of commercial properties. They invest a significant amount of resource to protect their business but they are unable to get support and/or funding from the government (e.g. local council and the Environment Agency), which they find very disappointing and frustrating. The engagement from the local businesses, which is in a multi-cultural neighbourhood, is very low as many of them are not aware of flood risk to their businesses and properties and the importance of flood resilience. There is no government or alternative databases that can provide useful information of practical flood resilience practices. What they have done is through their own ingenuity and resource.

Case No 2: Business centre

Flood experience

This property, restored and refurbished from a historical flour mill and located next to a river, is a 6 storeys business centre for office hire in the north of England (see Photo 11 and 12). The river burst the bank before but only to the car park so they never thought about the risk of being flooded. It was flooded in 2007 for only the 2nd time (the first time was in 19th century), and has not been flooded again since then but have a couple of occasions of close calls.

Photo 11 /12 Business centre by the river



During the 2007 flood, the water in the river had been building up for days so they saw the flood was coming and had time to move all the furniture and computers and everything else on the ground floor offices to the upper floors. The ground floor of the building was flooded to about 1m deep. When the Red Flood Alert was issued, the building had already been flooded for 4 hours. The water receded after 12 hours. The business centre and the tenants returned back to work the next day thanks to the actions taken beforehand. And all the intellectual properties had been protected. But it took 3 months to dry out and sanitise the brick walls, rewiring and changing carpet, which was still relatively quick compared to many other properties nearby. During that time, the resources available (e.g. skips, electricians and plumbers) were stretched so it took longer to do things. It costed £26,000.00 to repair the damage.

When reflecting on the flood and action taken, the manager said:

“So from a management point of view, because we acted so quickly, because we got the tenants moved, put them somewhere else and basically saved them from the floods, okay, we had an improved reputation. We didn't lose any tenants.”

Flood strategy

After the 2007 flood, they realised that flood risk is real for their property, and a three stage flood plan was developed so staff know what to do next time when a flood alert is issued. They can communicate with the tenants and instruct them during the flood emergency. They also check the nearby monitoring station regularly during the flood season so they can have their own prediction (in case that the flood warning from the Environment Agency is too late like last time) and prepare in advance.

Local community and support

After the 2007 flood, a defence wall was built along the river by the local council (see Photo 13, 14 and 15), and it held on a number of risky occasions since. Money was raised through a business improvement district scheme from the local businesses to which they contributed £5000.00 along with their business rate and the money raised was also matched by the local council and EU funding. They are really happy with the results as the defence wall had held the water on quite a few occasions since.

Photo 13/14/15 Flood defence wall along the river



The local council set up a flood defence project group which would meet about every three to six months to report on what is going on in the area, how the funding is going, and where the money is being spent. This works extremely well.

Resilience measures

They also installed their own flood gates (see Photo 16 and 17) at a cost of £6,000.00 plus some very low annual maintenance expense (e.g. sealants), which provides very good value for money to them. The manager commented on the flood gates:

“Whenever we get an Amber warning, they go up. Yeah. So that people can see. It's more a reassurance for our tenants because we know those ones out there are brilliant. I'm all for our tenants, peace of mind. And they felt safe there now.”

The flood gates provide a watertight barrier to all the external doors of the property. If budget allows, they would like to upgrade their floodgate to the more durable ones made of metal.

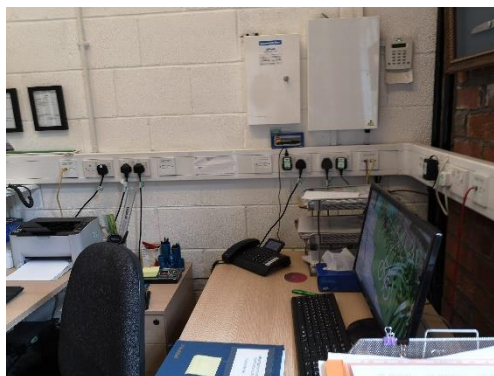
Photo 16/17 Flood gate



By the time their insurance was due 9 months later, after showing the insurance company their flood strategy and flood defence measures in place, their insurance premium was not increased but they had to accept significantly higher excess amount.

They were ignorant about the fire risk during the flood before and learned the lesson during the 2007 flood. Therefore, they raised the power sockets 1m above the ground in the ground floor offices (see Photo 18) because the damage would be more expensive.

Photo 18 Raised electrical sockets in the ground floor office



Case No 3: Holiday cottage

This property is holiday cottage in the Midlands. It is located on a raised pavement in front of the nearby river (see Photo 19). It was flooded in 2007 with 2 feet of water inside the property, which was deemed as a once in a hundred years event, but has not been flooded since.

Photo 19 Holiday cottage by the river



Insurance and recovery

During the flood, the water came into the ground floor and caused some damages. The owner claimed £34,000.00 from the insurance company. Although the insurance premium has not been increased much since, the excess amount has been increased significantly (from £100.00 to £3,500.00). After the flood, the recovery took nearly a year as everyone in the town was fighting to find good tradesmen to do the work, so there was significant income loss.

Resilience measures taken

The kitchen units were completely damaged so these had to be replaced (still the fixed traditional wooden unit as it is rather small and not too expensive to replace, and it is better to replace it due to bio hazard after the flood anyway). But the replacement kitchen appliances such as cooker and fridge are now portable (see Photo 20) so they can be moved to the upper floor during the flood next time. They also raised the power sockets to a higher level (see Photo 21) to have a certain degree of protection.

During the repair, the plaster had to be stripped down, and replaced with traditional lime plaster which is more resilient to flooding and dries more quickly. A flat stone floor (see Photo 22) was installed as this is resilient and easier to clean after a flood.

Photo 20 Portable kitchen appliances



Photo 21 Raised power socket



Photo 22 Flat stone for floor



The owner also installed an electric pump (costing £500 – 1000) underneath the floor (see Photo 23/24) at the entrance so it can pump out the water quickly if it is flooded again. An air vent was also installed (see Photo 25) to keep the damp out.

Photo 23/24 Electric water pump at the entrance



Photo 25 Air vent



When asked why not installing a flood gate to prevent water coming in, the owner said they did consider it, but they worried that it would put off the future potential buyers due to the fact that the property has been flooded / prone to flooding and devalue the property. Plus it does not look nice on the property. But the owner also believed that people's attitude is changing now, and the flood measures such as temporary flood gate may be a good thing to future potential buyers as it shows the property is properly protected, and some companies can provide the flood gate which looks very similar to the existing door so it is unlikely to affect the property aesthetically. The owner also mentioned that if you choose to live by the river, you should have the right mind-set and prepare for the possibility of being flooded.

Support available

All the protection and resilience measures are from life experience and observation of neighbours' practice. There is a local flood forum for flood information which is very useful. The Environment Agency's warning system works well as they will send you the flood warning by phone and text. The Environment Agency did an assessment after the flood, and concluded that it was not cost effective to have any protection barriers along the river. The owner hopes that the Environment Agency could do some work to slow down the flow of

water from the hills by the use of nature based solutions, including not straightening the river and the use of farm land to absorb the flood water.

Case No 4: Sailing club

Flood experience

This property is a sailing club by a river bank in the north of England (see Photo 26 and 27). It has been flooded multiple times in the past, and flood has become more frequent, with the last in February 2021. They have accepted that they have to learn to live with water due to the more frequent flood events, the location of the property and the nature of their club. Flooding normally happens in winter, which is not the sailing season, so the interruption to the business is not as significant.

Photo 26/27 Sailing club by the river



Local community and support

The Environment Agency did an assessment on the village regarding the flood defence project, but concluded that such a project was neither viable nor effective. Instead, they offered £7,500.00 for individual property owners to work on flood resilient measures themselves. In the past, the local council offered some flood resilience grant after the large flood events in 2015, which required a surveyor to assess and design according to individual properties. However, they missed out on that opportunity and instead had to fund the measures themselves.

Resilience measures

In order to be able to monitor the flood situation remotely, they installed a camera in the property, and they also have registered flood alert / warning with the Environment Agency so they can act quickly. After the previous flood, the insurance premium for the property has not been increased too much, probably because flood is expected due to its location.

In order to prevent water coming into the property, they installed a flood gate at the main entrance (see Photo 28), which has worked in the past. Learning from their previous

experience, they also raised the power sockets above 1.2m to avoid the damage during the flood (see Photo 29). They also moved the heavy and soft furniture upstairs and only leave some very simple and easy-to-clean tables, steel chairs and benches on the ground floor which has a hard floor to resist flood water (see Photo 30 and 31).

They did consider raise the floor level but couldn't due to the restraint of the ceiling height. However, they plan to relay the floor so the water can be drained to one point or a gallery to be pumped out more quickly. As it is an old building, the structure is not strong enough to resist the hydraulic pressure and keep water out.

Photo 28 Flood gate at the main entrance

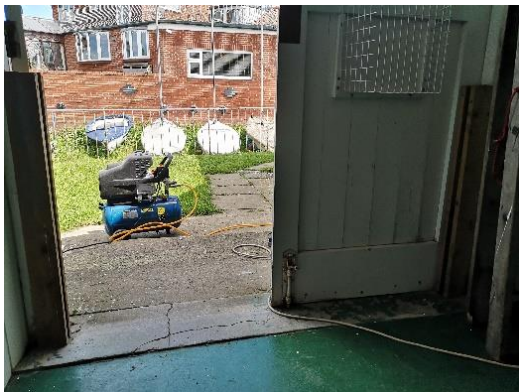


Photo 29 Raised electricity sockets



Photo 30/31 Hard floor and easy-to-wash tables and chairs on the ground floor



In the storage room, the petro tank is placed at the raised level so it will not be damaged and cause pollution in the event of a flood (see Photo 32). They also have raised shelves in the storage room to be able to move valuable equipment above the water level or to the 1st floor of the building (see Photo 33).

Photo 32 Petro tank on raised stand



Photo 33 Raised shelves in the storage room



When asked if they would consider to use cement or other water proof paint on the external wall, the manager said the problem of that is when the cement plaster or water proof paint gets old, it will crack and water will seep in and be trapped there and damage the structure of the property. Instead, they will use the natural and breathable clay paint so the wall can dry more quickly after the flood.

Case No 5: Rowing club

Flood experience

This property is a rowing club by a river in the Midlands (see Photo 34). The main building has two-storey with a gym (see Photo 35), two squash courts, a bar, some offices and a boat house, and affiliated outdoor tennis courts.

Photo 34 Rowing club by a river



Photo 35 Gym room on the ground floor



The property has been flooded multiple times, with the most severe being in 2007 (see the Photo 36 with the club building in the middle) with the water as deep as 1.7m on the ground floor (see Photo 36 and 37).

Photo 36 Biggest flood in 2007



Photo 36 / 37 Marks of flood inside the building



Insurance

The property is insured but the excess amount is high at £5000.00 so it is not worth to claim the damage if the flood is not too severe. And the club members helped the cleaning-up work themselves to reduce the cost. The degree of damage and interruption depends on the level of flood. If the flood only comes to the lowest level in the boat house, it is rather easy to wash and clean and within a week the club can operate normally. But if other parts of the building is flooded, it would take as long as 2-3 months to be back to normality. The flood damage would normally range from £1000.00 to £4000.00.

Resilience measures

After the 2007 flood, they moved the bar from the ground floor to the 1st floor so it will not be affected anymore, and used the space as an exercise room and the equipment can be moved to upper floor easily in the event of flood and the hard floor is easy to wash and clean (see Photo 35).

The main issue from the flood is the wooden floor of the squash courts (see Photo 38). They had to remove the side boards and tins before the flood to allow the floor to partially float and the boards to swell without buckling (the floors expanded by on average 40mm during the flood), and dry the floor by using fans and radiators running 24/7 for days (see Photo 39). The whole work costed them £800.00 with volunteers from the club (which would have costed £12000.00 at the market price). In the end, it took them 3-4 months to restore the squash courts. The club has decided to raise the floor of the squash courts to above the flood line, which is very costly as it requires a new roof as well, but this will make the squash courts flood proof, and the space underneath can be used as a gym.

Photo 38 Squash court on the ground floor Photo 39 Repairing the squash court after flood



They did consider flood gate to prevent water coming into the building, but gave up in the end as there are so many water entry points in the building including the floors, so it is not practical.

They have their flood plan so everyone knows what to do in the event of a flood emergency which is also well rehearsed. They have registered with the Environment Agency's flood alert. They need to predict the flood level in order to decide whether they need to lift up the boats (which are rather expensive with each costs thousands) in the boat house (see Photo 40). They have to act early because the property will not be accessible during flood. In the biggest flood in 2007, they had to move all the boats off site as the water level was too high and the boats would float around and get damaged. The boat house is at the lowest level of the building, but it is designed to allow water in so low level flooding is not a problem. It also has a hard floor and so can withstand the flood water and is easy to clean. Whenever possible, they created raised storage above the floor (see Photo 41) and the switch board and power are also put at higher level to reduce flood risk (see Photo 42).

Photo 40 Rowing boats on shelves



Photo 41 Storage off the floor



Photo 42 Switch board and power high above floor



Case No 6: Touring theatre

Flood experience

This property belongs to a touring theatre company in the north of England. The ground floor of this property has three different levels with about 30cm difference between each level: the office (lowest, with carpet), the reception area (middle, with carpet) and rehearsal area (highest, hard floor). It is very close to a river and it has been flooded twice in the past 20 years, with the latest in 2015. They were rather casual about the risk of flooding before, but the 2015 flood hit them hard as it happened on Boxing Day and not many staff were around to deal with it. The office and reception area were flooded, and they had to move the furniture and equipment (including two printing machines at a cost of about £170 to be removed by the technicians from the manufacturer) to the rehearsal area, and replace the floor board and carpet afterwards. They claimed £11,700.00 from the insurance company

and as a result, their insurance premium was increased. It took 3-4 weeks for them to be back to normal business.

Local community and support

There has been some discussion about the installation of movable temporary flood defence with the local council and the Environment Agency but it seems this may not be very practical and cost effective.

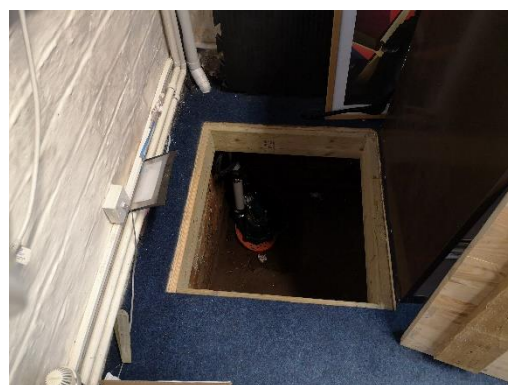
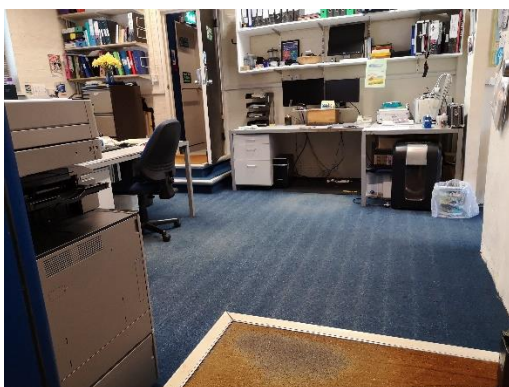
Resilience measures

After the 2015 flood event and in order to choose the right level of protection and achieve the right cost benefit themselves, they asked a consultant company to do a flood risk assessment and recommend some flood resilience measures. They then raised some funds from their patrons to implement them.

The first measure is a water pump under the office floor (see Photo 43 and 44) which can pump out the water automatically once the property is flooded. The pump has been tested by a real flood once and it worked properly. But the manager's concern is the pump is plugged in the normal power main and he is not so sure whether they need to invest in a generator in order to guarantee it will work in the event of flood. But this is a very specific professional job which he does not know whom he can turn to for advice:

"I sort of get lost in the world that way as soon as you start. You need an expert to come in and tell you how to do it because I need a generator that is not going to be generating fumes that I can exhaust safely. I need to store this generator somewhere in the building, so it has to be compact and safe and most of us to be able to use as well, and affordable."

Photo 43/44 Electric pump under the floor in the office



They also installed flood gates at each of the external doors to keep water out during flood (see Photo 45 and 46). They attached detailed instruction on the flood gate boards so anyone in the company can operate (see Photo 47). They also prepared some kits to use in the event of flood (see Photo 48).

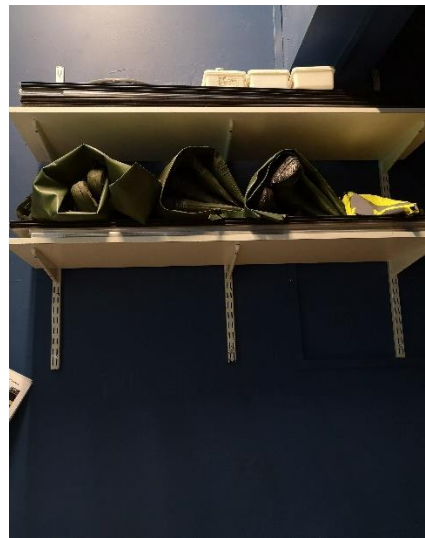
Photo 45/46 Flood gates at the external doors



Photo 47 Flood gate boards with instruction



Photo 48 Kits for flood



They also installed the air vent (see Photo 49) and overflow pipe (see Photo 50) to let out the water in the event of flood.

Photo 49 Air vent on the wall



Photo 50 Overflow pipe



They have registered on the flood alert system, but do not find it particularly accurate and useful. Due to the requirement of GDPR, they do not store physical documents anymore and all the sensitive documents are digitised. They have also raised most of their storage facilities with the exception of a filing cabinet which can be moved into a trolley.

6.3 Analysis and discussion

Flooding experience

As this research targeted areas historically prone to flooding, it is not surprising that 80% of the businesses surveyed have experienced flooding with two thirds experiencing multiple times. From the case studies, there is a consensus that flooding will happen more frequently and more severely due to the climate change, and we have to learn to live with water. This aligns with the principle of the national Flood Risk Management strategy (Environment Agency, 2020). However, many interviewees in the case studies reflected that they only realised the flood risk once they were flooded, and many of their neighbouring businesses are not paying enough attention to flood. Therefore, there is an urgent need to raise the awareness of flood risk among commercial property owners, especially those who are located in flood prone areas but have not yet been flooded. Businesses need to realise that flooding will not only cause the tangible and direct damages to their properties and operation but also intangible and indirect damages. Some local organisations such as local flood forum can play an important role in this, and local councils and Environment Agency can also organise road shows to publicise the good practice for flood resilience so more businesses will appreciate the benefits of PFR measures to protect their businesses.

In the survey, nearly three quarters of the respondents reported no increase of their insurance premium after the flood, and this was also confirmed in the case studies, but the excess amount has been reported to increase significantly. This means that although the businesses may be able to enjoy a stable insurance premium, they do have to bear more cost once a flood occurs. This shows the evident financial benefits of PFR in commercial properties as PFR measures can effectively reduce and/or minimise the damages from flood. They will be particularly important to the uninsurable properties like in Case No 1 as they may determine if a business can survive or not in an event of flood.

Flood risk protection measures

In the survey, the awareness of the flood protection measures is evidently higher than that of both resistant and resilient measures. This may relate to our human's instinct to protect our property in the appearance of risk. According to the survey, the most popular protection measure is to move the vulnerable / valuable items above the expected flood level. It is also the 2nd most implemented protection measure. This measure is cost neutral and very easy and quick to implement. Not surprisingly, this measure has also been implemented by all the six properties in the case study. But the challenge with this measure is that sometimes

the flood comes too quickly for people to have time to move things, or the flood comes at an inconvenient time (e.g. a bank holiday weekend in Case No 1 and Christmas in Case No 5 and No 6) when not many staff are around. Some items may also be too heavy to move easily (e.g. the printing machine in Case No 6). Hence, as flooding becomes more frequent and severe to break historical records, this measure may be simple and easy to implement, but it is too reactive and may not work every time.

The majority of the commercial property occupants are acutely aware of the importance of business data / files and have mostly digitalised their database, as exemplified in Case No 1, No 2 and No 6. But as pointed by the operational manager in Case No 1, flood risk is not always the top priority for everyone and sometimes people are occupied with day-to-day business operations. It takes time to change the organisational culture. There is an urgent need to raise the awareness of flood risk and incorporate the flood resilience strategy into the overall business risk management strategy, as done in Case No 1.

Raising equipment and machinery on plinths is also a popular protection measure among the participants surveyed, which is strongly supported by the case studies (see Photos 7 – 10, 32, and 41). This measure is more permanent and does not cost much to implement, but the benefit can be very significant as it can protect equipment, machinery and raw materials so the businesses can minimise the damage from the flood and resume operation much more quickly after flood. Businesses are encouraged to assess their own business practices and take on this measure to suit their specific needs.

Registering for flood alert / warning is the most popular flood risk protection measure implemented in the survey, and this is further confirmed in the case studies. This measure is cost neutral and can help businesses monitor the flood movement in real time and prepare in advance. But the challenge is that the alert / warning is not always very accurate, or comes in too late to have time to react, or comes in an inconvenient time (e.g. late at night or weekend) for businesses. However, with the rapid development in flood forecasting techniques from more powerful computer capacity and the application of AI, it is expected the accuracy of the flood forecast will be improved significantly in the coming years (Sankaranarayanan et al., 20020) and businesses will benefit greatly from the flood alert / warning system.

In the survey, although the water pump is the least aware protection measure, it is the equally 3rd most implemented one, and is also witnessed in the cases No 3 and No 6. The cost of a water pump is moderate but it can speed up the recovery after flooding so it can play an important role in the flood resilience for commercial properties.

Flood defence project (like the flood defence wall in Case No 2, shown in Photo 13, 14 and 15) can be very effective, and the businesses are willing to contribute to the cost of such projects in the form of business rate as they are the ultimate beneficiaries. However, these kind of projects are normally very expensive with a lot of restraints so need the coordination from the government, local authorities and other organisations such as the Environment Agency. Also on occasion, such projects may not always be effective or viable and can also be overtopped (like the Case No 3 and No 4). Therefore, businesses should not rely on this

kind of flood defence projects but need to take a more proactive approach to tackling latent risks including the installation of PFR measures specific to their own needs.

Flood resistant measures

Compared to flood protection measures, business occupants are less aware of flood resistant measures and less likely to implement them. The reason behind this may be because the flood resistant measures require to make some changes to the property which may be more costly but not very easily and conveniently to implement.

Flood gate (door and window guard) is the most popular flood resistant measures people are aware of and the most implemented in the survey. This measure is also proved very effective to keep water out in the case studies (Case No 2, No 4 and No 6, see Photos 16, 17, 28, 45 and 46). This measure is relatively easy and cheap to install, use and maintain, and the added benefit is that it gives tenants and potential buyers a peace of mind and the confidence that the property is well protected, as indicated in the case studies (Case No 2 and No 3). The reputation of the businesses can be improved as a result. This shows that PFR measures can reduce not only the tangible damages, but also the intangible and indirect damages to the commercial properties and businesses identified by Merz et al. (2010). But this measure may not be always effective if a property has multiple water entry points (e.g. Case No 5).

Airbricks and vents are the second popular flood resistant measures and they are also implemented in Case No 3 and No 6 (see Photo 25 and 49). It is very interesting to note that although waterproofing of the external wall is seen moderately in the category of flood resistant measures, the manager in Case No 4 emphasised more on the traditional breathable mortar and plaster on the external wall to allow water coming out quickly after flood in order to minimise the damage to the structure of the building. This is also agreed by the owner of Case No 3.

Flood resilient measures

Raising electrical sockets above likely flood level is the most aware of and implemented flood resilience measure in the survey. This has been confirmed by most of the case studies (please see Photo 7, 8, 18, 21 and 29). A closely related measure of moving gas and electric meters above likely flood level is also relatively well received in the survey and the case studies (please see Photo 42). This two measures are relatively easy to implement and can ensure the property to resume function quickly after the flood. This needs to become a standard practice in the new build projects to avoid the extra cost of retrofit later. This can be achieved through update the building code and better education and training of designers.

The 2nd most popular and 3rd most implemented flood resilience measure in the survey is 'replace carpet floor finishing with floor tiles', as demonstrated in Case No 1 (see Photo 1). This measure has been proved very effective as the (carpet) tiles can wash and dry easily after flood and put back. And the 3rd most popular and equally most implemented flood

resilience measure in the survey is 'Installing concrete floor instead of timber floor'. In the case studies, property owners prefer hard floor, as shown in the Case No 3, No 4 and No 5 (see Photo 22, 30, 31 and 35). The benefit of the hard floor is that it is very easy to wash clean and can return back to use very quickly. The squash court in Case No 5 (see Photo 38 and 39) shows the opposite as it would be very costly to restore wood floor or carpet floor.

Another flood resilient measure observed in the case studies is the use of stainless steel kitchen units and simple furniture (see Photo 3, 4, 30 and 31). This allows facilities to be washed clean easily and go back to work quickly. This will save a lot of cost and hassle in the event of flood.

In the case studies, except one case (in Case No 6 the business asked a consultant company to do a formal assessment and recommend specific flood resilience measures), the businesses complained about the lack of information and knowledge regarding the available flood resilience measures. They have to either follow their neighbours' practice or turn to the internet for information. There are very limited flood resilience measures available on the market and the products available may not address the businesses' specific needs. The publication of *Code of practice for flood resilience measure* (Kelly et al., 2019) is a welcoming first step in the right direction. However, there is an urgent need for the government / professional bodies such as RICS, CIRIA and BRE to provide a 'go-to' hub to provide the information businesses need in terms of flood resilience measures (e.g. the cost-benefit analysis of each measure, and the trusted manufacturers and contractors, etc.).

Chapter 7 Conclusions

From the combined findings of the desk study, questionnaire survey and case studies, the following conclusions can be made from this research:

1. The detrimental impact from flooding on commercial properties is clearly evident. The impact manifests in different forms, including direct or indirect and tangible or intangible impacts, such as interruption to business, lost revenue, cost for recovery and increased excesses in insurance. Businesses clearly have to take flood risk seriously and take action to minimise these impact.
2. The flood risk awareness is high among the participants of this research, but this is probably due to the fact that this research targeted commercial properties located in flood prone areas and the majority of the participants have had direct flooding experience. This high flood risk awareness, however, cannot be confidently extended to other commercial property owners and occupiers who have not been exposed to flooding. More effort is still needed to raise the awareness among commercial property occupants as the likelihood of flooding is increasing due to a range of factors including climate change. As such, businesses need to prepare themselves for these events in order to mitigate their risks.
3. A number of commercial properties have taken up PFR measures in a practical way to suit their business needs and these PFR measures seem to be working well in practice. The protection and resistant measures tend to be easier and less costly to implement and as such seem more popular than the resilience measures. However, the resilience measures are often more permanent in nature and are more effective in the long term. Rather than implementing a full suite of all available PFR measures, this research has shown that often, owners will choose a bespoke package of measures and that these can provide sufficient and effective protection to businesses from flooding.
4. PFR measures can not only reduce the damages from flooding, but also enhance the reputation of the businesses and increase the value of the properties, as shown in the case studies in this research. Therefore, besides the direct and tangible benefits of PFR measures, the indirect and intangible benefits should also be highlighted to promote PFR measures to businesses. This also highlights the need to fully appreciate the wide range of benefits that can be attributed to PFR measures, which would better facilitate businesses' decision-making in investing on PFR measures.
5. Many businesses lack sufficient knowledge on PFR measures and have to rely on their own instincts or follow other people's practice. Businesses urgently need support and help in terms of PFR measures. Specialist consultancy companies can play an important role by conducting comprehensive assessment on the flood risk and recommending effective PFR measures, but the cost of such assessment may be a barrier, particularly for SMEs.

Chapter 8 Recommendations

Based on the research findings, the following recommendations are put forward to improve the flood resilience of commercial properties:

1. Flood resilience should be part of an organisation's business risk management strategy and incorporated into its operational management.

Flooding can have a significantly detrimental impact on businesses. Flood risk is real and increasing and therefore businesses should incorporate flood resilience into their risk management strategy and daily operational management so they can be better prepared for future flood events.
2. Businesses need to assess their flood risks and implement specific PFR measures to address their own needs.

There is no 'one-fit-all' approach and each business is likely to require a different combination of PFR products to improve their flood resilience. Due to different geological locations, building types and nature of the business, businesses are exposed to different flood risks. Individual businesses need to tailor their PFR measures to their specific conditions and business needs in order to achieve the maximum cost effectiveness.
3. Further research on the cost benefit analysis of PFR measures is needed.

To implement PFR measures, businesses have to be able to justify their investment with their shareholders and they also have financial targets to meet. However, at the moment, there is lack of information on the costs and benefits of different PFR measures, which affects the businesses' decision making on implementing PFR measures. A comprehensive research on the costs and benefits of different PFR measures will facilitate and encourage more PFR measures in commercial properties.
4. A 'one stop' hub for PFR measures is needed to provide the information needed for businesses.

At the moment, businesses tend to rely on their own limited knowledge and experiences to find their way in terms of PFR measures. There is no database or contact point available for good practice. There is an urgent need for the establishment of a 'one stop' hub from not-for-profit organisations (e.g. government or professional bodies) to provide independent, reliable and practical advice and guidance on PFR measures. There is clearly scope for RICS members and other relevant professionals to take an active role in the provision of this expertise and professional advice in what will be a growing market in the future.
5. PFR measures should be incorporated in the building design and construction.

Many of the common and tested PFR measures such as raised power sockets and water proof external wall can be very easily incorporated into the design and

construction of new commercial properties with no or very little extra cost. This will save a lot of time and cost compared to retrofitting these PFR measures later on. Commercial property owners should explicitly specify PFR measures in their project briefs from outset of their capital investment.

References

- Adedeji, T.J., Proverbs, D.G., Xiao, H. and Oladokun, V.O. (2018) Towards a Conceptual Framework for Property Level Flood Resilience. *International Journal of Safety and Security Engineering*, 8(4), pp. 493 - 504
- Bhattacharya-Mis, N. and Lamond, J. (2016) Risk perception and vulnerability of value: a study in the context of commercial property sector. *International Journal of Strategic Property Management*, 20(3), pp. 252-264
- Brace, I. (2018) *Questionnaire design: How to plan, structure and write survey material for effective market research*, Kogan Page Publishers
- British Property Foundation (2014) *Property data report 2014*, London: British Data Foundation
- Chang, S.E. and Falit-Baiamonte, A. (2002) Disaster vulnerability of businesses in the 2001 Nisqually earthquake. *Global Environmental Change Part B: Environmental Hazards*, 4(2-3), p. 59–71
- CIRIA and Environment Agency (2003) *Flood protection products – a guide for homeowners*. CIRIA, London, London: CIRIA
- Climate Change Committee (2016) *UK Climate Change Risk Assessment Evidence Report*, Climate Change Committee, London
- Department for Communities and Local Government, 2007. *Improving the Flood Performance of New Buildings: Flood resilient construction*, London: Department for Communities and Local Government
- Dhonau, M. and Rose, C.B. (2016) *A Business Guide to Flood Resilience*, UK: MDA Community Flood Consultants
- EKOS Consulting Ltd (2008) *Evaluation of Yorkshire Forward's Flood Response*, Sheffield: EKOS Consulting (UK) Ltd
- Environment Agency (2009) *Flooding in England: a national assessment of flood risk*, Bristol: Environment Agency
- Environment Agency (2014) *Flood and coastal erosion risk management Long-term investment scenarios (LTIS)*, Bristol, England: Environment Agency
- Environment Agency (2020) *National Flood and Coastal Erosion Risk Management Strategy for England*, Environment Agency
- Fricker, R. D. and Schonlau, M. (2002) Advantages and disadvantages of Internet research surveys: Evidence from the literature, *Field Methods*, 14(4), 347-367
- Haigh, I. D., Nicholls, R. J., Penning-Roswell, E. & Sayers, P. (2020) Impacts of climate change on coastal flooding, relevant to the coastal and marine environment around the UK. *MCCIP Science review*, Volume 1, p. 546–565
- Jha, A.K., Bloch, R. and Lamond, J. (2012) *Cities and flooding: A guide to integrated urban flood risk management for the 21st century*. Washington DC: The World Bank
- Kelly, D., Barker, M., Lamond, J., McKeown, S. and Blundell, E. (2019) *Code of practice for property flood resilience (Edition 1)*, CIRIA, London
- Kenney, S., Pottinger, G., Plimmer, F. and Pocock, Y. (2006) *Flood risk and property: Impacts on commercial and residential stakeholders' strategies*, Whiteknights, Reading, RG6 6AW: College of Estate Management

Lamond, J., Bhattacharya-Mis, N., Chan, F.K.S. and Kreibich, H. (2017) *Flood risk mitigation and commercial property advice: an international comparison*, London: RICS

McAllister, T. (2013) *Developing guidelines and standards for disaster resilience of the built environment: a research needs assessment*, NIST: US Department of Commerce

Merz, B., Kreibich, H., Schwarze, R. and Thieken, A. (2010) Assessment of economic flood damage. *Natural Hazards Earth Systems Science*, Volume 10, pp. 1697-1724

Moudrak, N. and Feltmate, B. (2019) *Ahead of the Storm: Developing Flood-Resilience Guidance for Canada's Commercial Real Estate*, University of Waterloo: Intact Centre On Climate Adaptation

ODPM (2003) *Preparing for Flood: Interim guidance for improving the flood resistance of domestic and small business properties*, London, UK: Office of the Deputy Prime Minister

Oladokun, V.O., Proverbs, D.G. and Lamond, J. (2017) Measuring flood resilience: a fuzzy logic approach, *International Journal of Building Pathology and Adaptation*, 35(5), 470-487

Pottinger, G. and Tanton, A. (2011) *Waterproof – flood risk and due diligence for commercial property investment in the UK*, Reading: The College of Estate Management

Sankaranarayanan, S., Prabhakar, M., Satish, S., Jain, P., Ramprasad, A. and Krishnan, A. (2020) Flood prediction based on weather parameters using deep learning, *Journal of Water and Climate Change*, 11 (4), 1766–1783

Tagg, A., Laverty, K. and Escarameia, M. (2016) *A new standard for flood resistance and resilience of buildings: new build and retrofit*, s.l.: FLOODrisk 2016 - 3rd European Conference on Flood Risk Management

Thieken, A.H., Ackermann, V. and Elmer, F. (2008) *Methods for the Evaluation of Direct and Indirect Flood Losses*. Toronto, Ontario, 4th International Symposium on Flood Defence: Managing Flood Risk, Reliability and Vulnerability, May 6-8

World Meteorological Organization (2012) *Flood Proofing – A Tool for Integrated Flood Management, Version 1.0*, s.l.: WMO/GWP Associated Programme on Flood Management

Yin, R.K. (2011) *Applications of Case Study Research (3rd Edition)*, Sage

Zhang, Y., Lindell, M.K. and Prater, C.S. (2009) Vulnerability of community businesses to environmental disasters. *Disasters*, 33(1), p. 38–57

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