

Assessing property flood resilience for commercial buildings: some recommendations



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Foreword

The ever-growing problem of global warming manifests itself in many ways, not least a rapid rise in the number and severity of floods in nations around the world. According to the Red Cross, in 2022 record-breaking floods in Pakistan killed more than 1,700 people and over a million livestock, with nearly 8 million people displaced. But even without global warming, and even on a much smaller scale, flooding has always created many challenges, and more needs to be done to mitigate risks.

Understandably, much attention focuses on how floods threaten people's homes. But places of work are at risk too. That means that many, perhaps all, businesses need to assess their flood risks. And professional bodies within the real estate sector, along with governments, can help them with advice on how to do that.

I'm therefore very pleased that we at Property Research Trust have commissioned, and are now publishing, this excellent study by a team of researchers, providing clear guidance and advice for the profession and for policy makers. This report is based on case studies of events in the Midlands area of the United Kingdom, but its messages apply world-over. This is practical, empirical research with immediate value, and I am grateful to the research team for all their efforts and insights.

Alan Dalglish
Chair, Property Research Trust

Key messages

- › Given the fact that UK flood risk management policy has tended to focus on a 'living with water' policy and on the impact to the residential property sector, this paper has a focus on the commercial property sector where there has hitherto been scant research.
- › The significant role of commercial property in the UK economy means that the potential detrimental impact from flooding poses a considerable threat to the security of income from this asset class for a variety of stakeholders.
- › Six case studies highlight how a group of small- to medium-sized businesses located in the Midlands area of the United Kingdom implemented property flood resilience (PFR) measures.
- › The paper draws conclusions about how businesses have had to assess their flood risks and then implement specific PFR measures which address their needs. It then makes a number of recommendations for businesses, including the need to incorporate flood resilience into a business risk management strategy.
- › The report highlights the need for additional research in this area and the establishment, by government or professional bodies, of a 'one-stop' hub for businesses that provides independent, reliable advice on PFR measures.

Executive summary

Commercial property plays a significant role in the UK economy and represents a major investment asset for both the pensions and insurance industries. UK commercial property forms a significant portion of the economy, with an estimated turnover of £3.2trn and employing about 22.8 million people with an average growth rate of 2.2% since 2008.

Commercial property investment rental income derived from business leases on offices, shops, industrial and leisure facilities supports pensions, insurance policies and savings plans. Therefore flooding poses a considerable threat to the security of income from this asset class and means the security of these investments is paramount to the large number of shareholders and stakeholders.

In recent years, UK flood risk management policy has recognised that floods cannot be totally prevented and has therefore embraced a proactive and more robust approach of managing flood risk and living with floods, captured under the 'living with water' philosophy. This approach often entails building resilience into the system that is exposed to the risk.

For residential properties, the focus has been on 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). Since its inception, this has 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 them. The aim of this study, therefore, 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:

- a review of the existing evidence found in the literature, encompassing government reports, policy papers, grey literature and published research.
- an online questionnaire survey of commercial property owners and tenants exposed to flood risk.
- a detailed case study phase, in the York, Sheffield and Worcester area of the UK, 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 case study businesses were: a manufacturing factory; a business centre; a holiday cottage; a sailing club; a rowing club; and a touring theatre.

The findings revealed

The detrimental impact from flooding on commercial properties is evident in a number of ways, making a clear case for businesses to take flood risk seriously and to take action to minimise the impact.

Flood risk awareness among the case study businesses was high, but this was possibly due to the fact that most had direct flooding experience. Effort will be needed to promote awareness to businesses not currently at risk, to allow time to prepare risk management strategies.

The case studies showed that businesses tended to choose a bespoke package of measures to suit their circumstances, rather than implementing a full suite of all available PFR packages.

It was also evident that PFR measures enhanced the reputation of the businesses and increased the value of properties, providing indirect and intangible benefits, as well as reducing the damage from flooding – the principle direct and tangible benefit. Businesses need to fully appreciate the range of benefits into their PFR decision-making.

The case studies showed that businesses chiefly relied on their own resources and instincts, or followed the practices of others in developing PFR strategies. This points to the need for business support in this area, especially for SMEs.

Recommendations

- Flood resilience should be part of an organisation's business risk management strategy and incorporated into its operational management.
- The absence of a 'one-size-fits-all model' means businesses need to assess their own flood risks and implement specific PFR measures to address their needs.
- Further comprehensive research on the costs and benefits of different PFR measures will facilitate and encourage more PFR measures in commercial properties.
- There is an urgent need for a 'one-stop' hub organised by government or professional bodies to provide independent, reliable and practical advice and guidance on PFR measures.
- PFR measures should be incorporated into building design and construction, where appropriate, to avoid costly retrofitting later.

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). The impacts on health are also extensive and substantial, ranging from loss of lives and injuries from the flood event, to infectious diseases and mental health problems, including acute and long-term issues.

The impacts of flooding in the UK have been far-reaching with more than 5.2 million properties (around one in seven homes and businesses) exposed to some form of flood risk (Environment Agency, 2014). Estimates suggest that more than £220 billion worth of property is potentially at risk in England and Wales, from different sources including 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 between £1.8 billion 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 offer some resilience to flooding. It is, however, very difficult to sustain and many will be overwhelmed by the next 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 that flooding cannot be totally prevented and has embraced a proactive and more robust approach. This is encapsulated in the 'living with water' philosophy (DEFRA, 2005).

This approach 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). Since its inception it has

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.

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.

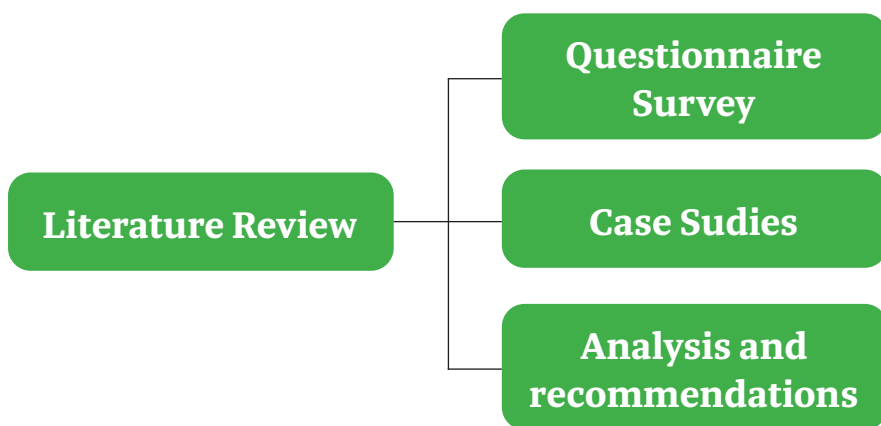
Chapter 3

Research methods

3.1 Research process

To achieve the aim and objectives of this research, a mixed methodology was adopted. The process started with a desk-based literature review to assess existing knowledge in the research area. A questionnaire was then developed based on this literature review and used to survey commercial property occupants who had been affected by flooding in the past. The survey findings informed a series of case studies. The primary evidence from both the survey and case studies was analysed to draw conclusions and produce recommendations to help the commercial property occupants 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, the 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 first 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, eliminating investigator 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

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 produced. A case study is research into a particular place, event or community which collects information using various approaches.

It allows detailed descriptions of particular instances of a phenomenon that are commonly based on different data sources (Yin, 2011). In this research, interviews, site visits 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). Their value is therefore 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 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 £98 billion) 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 £3.2 trillion, 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 on this security.

4.2 Flood risks to commercial property

It is estimated that around 185,000 commercial properties are at 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). Surface water flooding and flash flooding in urban areas also means that buildings and businesses located away from flood plains and coastal areas may also be exposed to flooding.

According to EKOS Consulting (2008), some of the impacts experienced by businesses during the summer floods of 2007 in Yorkshire include damaged or lost stock and equipment, damage to buildings/premises, inability to conduct business, and inconvenience to staff. The statistics on the 2007 floods emphasised the havoc flooding can wreak on business. Records show around 8,000 businesses were affected, resulting in 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 in 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 flooding of commercial properties is evident globally and seen to be prevalent in the UK (Lamond et al., 2017). Damage caused is associated in large part with the continuous interaction between the natural world 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	Structural damage Damage to furniture and fittings Loss of stock Damage to equipment and machinery	Loss of document Ill-health
Indirect	Loss of production Cost of evacuation of goods and staff Clearing and cleaning up cost Repair cost	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, referred to as secondary effects of flooding (Lamond et al., 2017). The tangible part of these impacts can be easily measured and claimed, such as damage to buildings and loss of stock. Intangible impacts, such as loss of reputation and issues with renewing insurance, are more difficult to measure and may have huge impact on a business in the long run (Lamond et al, 2017). Studies suggest 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, machinery, equipment and loss of stocks due to lack of mobility (Tierney, 1997; Zhang et al, 2009). Typically, enterprises with large fixed assets such as 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 thus relates to the potential cost of damage to physical structures or economic assets exposed to loss. Loss of business records can 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. Thereby losses are incurred through the time it takes to recover from the disrupted state of operation (Alesch et al, 1998; Tierney, 2007; Parker, 2009). So even if a business escapes

direct damage it may be forced to shut as a result of indirect impacts such as disruption to supply chains, 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 a 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 affected by the physical impacts of flooding on the 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

While 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 damages and ensure they are prepared against future risks (ASC, 2016). The little evidence available is often subjective in nature and mostly concerns small- and medium-sized enterprises (ASC, 2016).

Traditional flood defences may be available to provide protection against coastal and river flooding for large communities, but there will always be some commercial properties that would not benefit from such schemes. Such defences are unlikely 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) highlighted 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 a range of protection or resilience measures they can incorporate into their properties to mitigate 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 preparing in advance of flooding. In doing so 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 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 measures 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 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 and 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 storeys		√
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 of 600mm around a property, although in some cases surveyors may recommend this to be 300mm (ODPM, 2003). This will help to reduce damage to the internal fabric of the building and its contents such as stock, equipment and machinery, staff, customers and suppliers' records. This will in turn reduce the associated stress and suffering to business users and owners.

These measures provide property owners with the opportunity to relocate important items to a safer level in the event of a flood. To this end, 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 buildings (CIRIA and Environment Agency, 2003; ODPM, 2003) and some of these findings can also be applied to commercial properties with similar features. Ideally, floodwater would be completely 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, 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) hydro-static 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 buildings (World Meteorological Organization, 2012).

The advantage of applying resistance is that the building is kept dry and the contents (e.g. stock and valuable records) inside the building are not affected (TUHH, 2010). However, one of the disadvantages is that the stability of the building structure can be jeopardised due to 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, 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 – such as through careful selection of building materials, construction techniques and internal finishes – can help reduce the risk of flood damage to the business premises and the integral components inside. 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 contaminants (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 various techniques that should be applied to minimise the damage caused to the building and its contents. One is to ensure 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 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). And vulnerable items, such as utilities, appliances, computers and contents, should be 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 moving 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 policies in a secure, accessible place, as well as a copy in a 'grab bag' or 'battle box'
- 7) Ensuring drains from the premises are running efficiently.

Other measures identified are retrofits such as equipping elevators with water sensors to prevent them from entering flood-inundated building levels, and 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 limit their 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 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 six standards with the purpose of providing a 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 introduced to provide some useful insights into 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, 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%). More than a third of the properties were valued up to £250,000, and about a fifth were valued at £750,000.00-£1 million. The majority (87%) had fewer than 20 employees, and two-thirds had an annual turnover of up to £250,000. This shows the participants are mainly SMEs. Refer to Figures 1, 2 and 3 below.

Figure 1: Business type in the survey

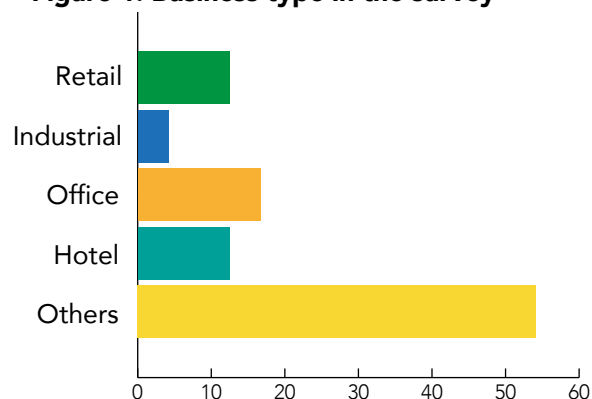


Figure 2: Value of the properties (%)

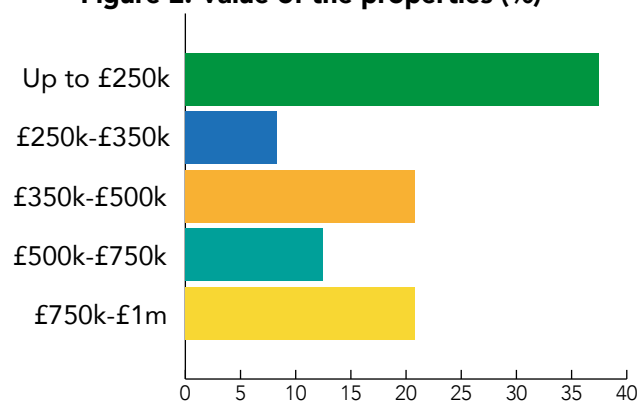
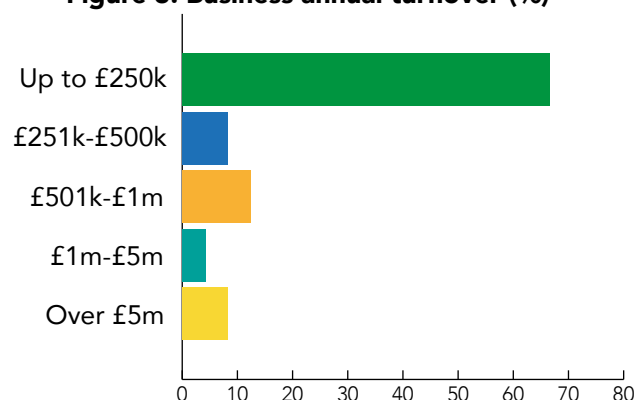


Figure 3: Business annual turnover (%)



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

Figure 4: Number of storeys (%)

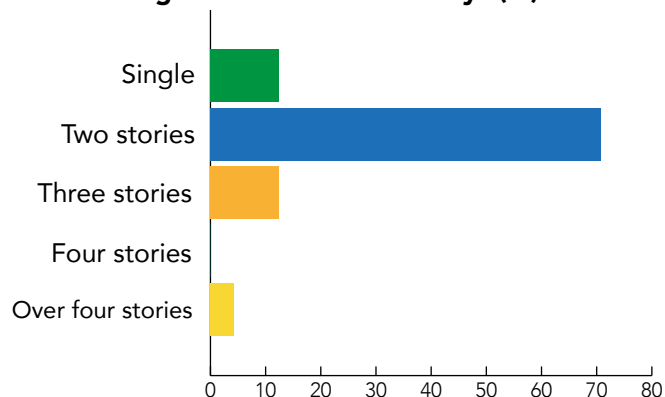


Figure 5: Approximate ground area (%)

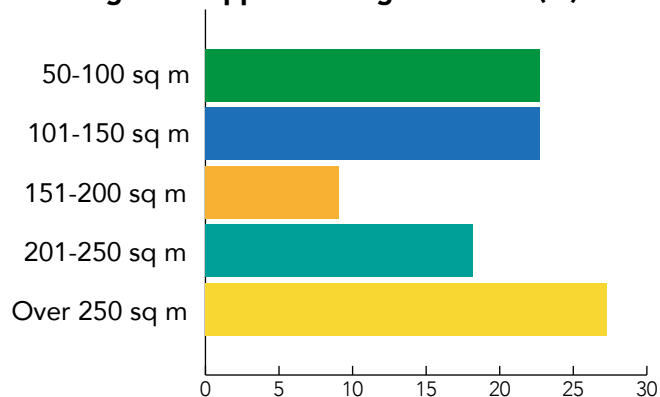
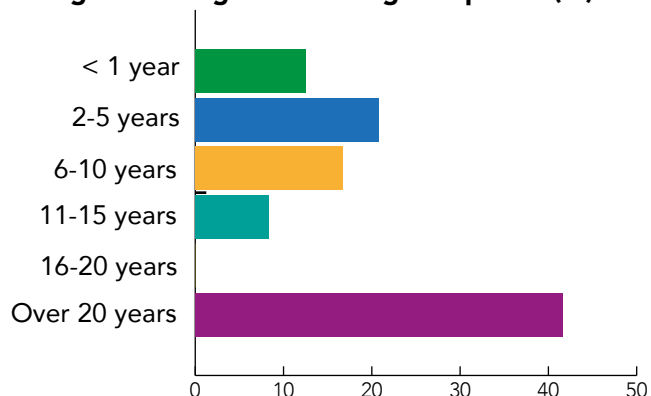


Figure 6: Length of building occupation (%)

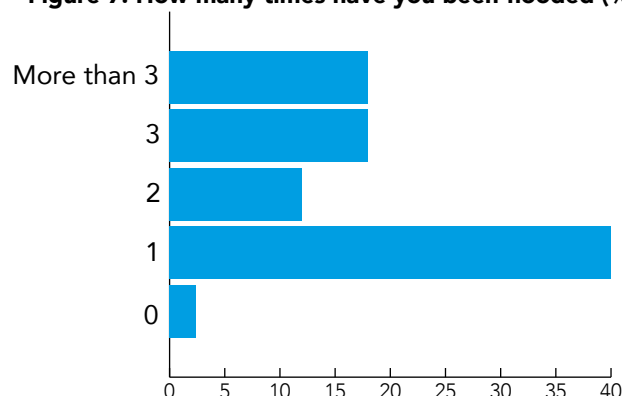


Flood experience

The majority of the participants had experienced flooding in their current properties. Two-fifths said their properties had been flooded once, and about half said their 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

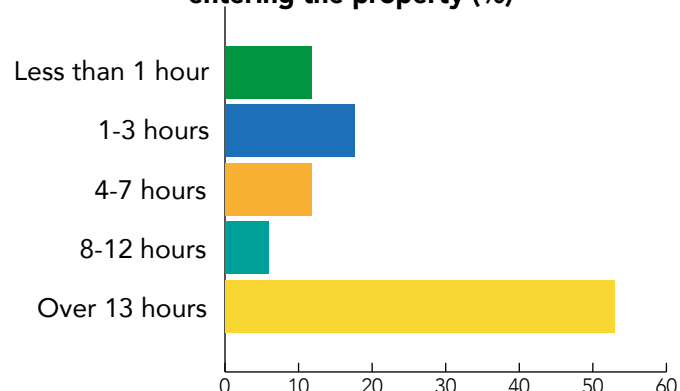
were being repaired after the flooding.

Figure 7: How many times have you been flooded (%)



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

Figure 8: Time between flood warning and water entering the property (%)



60% 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 reporting either moderate or high impact (see Figures 9 and 10).

Figure 9: Impact on staff from flooding

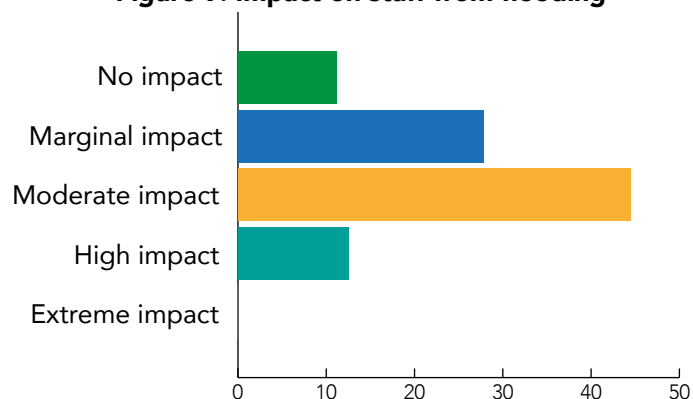
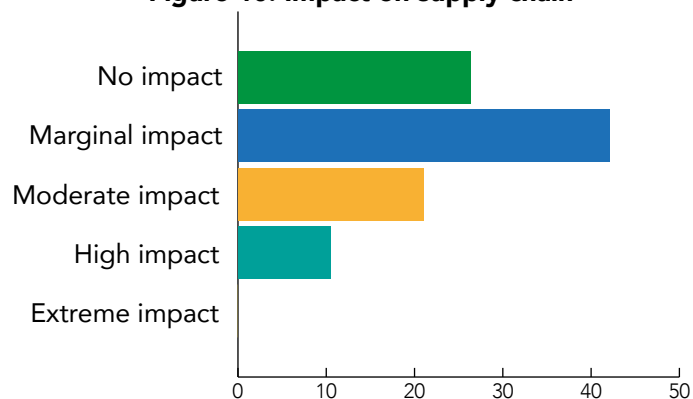


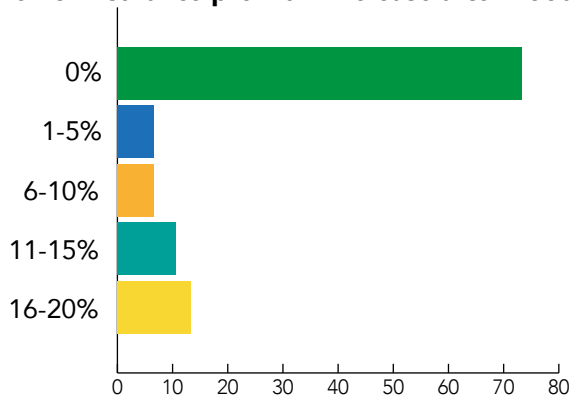
Figure 10: Impact on supply chain



A total of 75% of the participants did not experience any insurance premium increase after the flooding, with 15% reporting insurance premium increases of more than 15%.

Once the property was flooded, it took between one and 18 months to complete the repair work, with the average being five months. Cost of damage ranged from £100 to £250,000, with an average of £38,850. Only half of the businesses surveyed had an emergency flood plan in place.

Figure 10: 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	4.9	71
Keeping copies of customers' file in a safe place	4.8	46
Raising equipment and machinery on plinths	4.7	25
Relocating more expensive items above the expected flood level	4.7	54
Keeping copies of staff members' files in a safe place	4.5	46
Registering for flood warning	4.4	87
Use of sandbags to prevent water entering	4.4	36
Safe storage of supplier contracts	4.3	45
Moving stocks to another site	3.9	23
Generators to power pumps and emergency lighting	3.2	8
Sump and pump fitted	3.0	54

Flood-resistant measures

In this section, participants were asked to indicate their awareness of the flood risk resistant measures (1 being 'not aware', and 5 being 'fully conversant', and 2, 3 and 4 in between), and whether they had implemented any particular measures. Table 4 summarises 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	4.1	46
Manual airbricks and vents covers	3.6	38
Raised windows	3.5	17
Using water proofing membrane on external walls	3.3	8
Waterproofing of external walls	3.1	0
Installation of flood doors and door guards	3.1	0
Installation of non-return valve to prevent water coming through drains	2.9	0
Smart airbricks and vents that close automatically	2.8	8
Door and window guards that close automatically	2.4	0

Flood-resilience measures

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

Table 5 Awareness and implementation of flood-resilience measures

Resilience measures	Awareness	Implementation (%)
Raising electrical sockets above likely flood level	4.6	62
Replace carpet floor finishing with floor tiles	4.4	54
Installing concrete floor instead of timber floor	4.2	62
Moving gas and electric meters above likely flood level	3.3	31

Replacing normal plaster with water resistant plaster	3.2	25
Installation of hardwood flooring	3.2	8
Tanking of ground floor and basements	3.1	15
Replacing kitchen units with stainless steel units	2.8	8
Resin damp proof membrane beneath concrete floor, to prevent the water rising from underneath	2.5	15
Installing steel staircase	2.4	17
Replacing kitchen units with plastic units	2.3	8
Use of marine ply for kitchen units/cabinets	2.3	15
Installing concrete staircase	2.1	23
Fixing plasterboard horizontally instead of vertical fixing	2.0	8

6.2 Results from the case studies

To gain 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 take part. They represent 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 and is divided into different areas for production, storage, R&D lab, office and canteen. A small river passes by a few metres from the factory. It had flooded twice in 2007 and the latest flood was in 2018 when the river burst its bank due to heavy rains and a blockage downstream.

The flood caused around £1 million of damage in the form of raw materials, machinery and IT equipment, office and furniture. This excluded the cost of

the company's own labour carrying out cleaning and repairs, so the true cost could be well be 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. After the flood, although it only took two weeks for the business to get back to production, it took about nine 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 along the river side to hold the water back. It worked in the past, but failed in the 2018 flood. In fact, it may even have made the situation worse as it prevented the water to flow out later on.

A CCTV camera was installed to monitor the river and the business registered with the Environment Agency for flood warnings. But on this occasion, the flood alert was only received four hours in advance and the flood warning two hours in advance. To make things worse, it was a bank holiday weekend and no staff were on site, so there was not much that could be done to reduce the damage.

Flood strategy

After the 2018 flood, the company realised that flood risk is a real threat and it had 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."

The company appointed a manager responsible for incorporating the flood resilience into the business resilience strategy and operational management so it can prepare for future flood events and minimise the damage and interruption to production and customers. The operational manager said:

"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. Because we've suffered more than one type of incident, and a really good example is 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."

The flood strategy is constantly reviewed to address any new risks identified. As flooding will impact on every aspect of the business, everyone in the company is encouraged to propose any ideas or practices to improve flood resilience.

Resilience measures

During the 2018 flood, a huge amount of physical data that had been collected over the years was lost. 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 forklift trucks, which are essential to the operation of the site, are now parked at the top of the site so they have a better chance of being operational after a flood. Raw materials are now stored in barrels with watertight lids so they are protected from water and production can be resumed very quickly after flooding. This will not only minimise the financial damage but also reduce the lead time.

After the flood, the carpet in the office was changed to rubber-backed carpet tiles (see Photo 1). If it is flooded again, the carpet tiles can be jet washed, dried and reinstalled quickly and easily. This has been tested twice and proved to work well. The plaster boards have also been changed to a plastic alternative (see Photo 1.2) so they can be cleaned down and put back (this has not been adopted in the offices due to the acoustic effect).

In the kitchen, the company has installed stainless steel units (see Photo 3) and standalone tables (see Photo 4), which can be easily cleaned and put back to use after flooding.

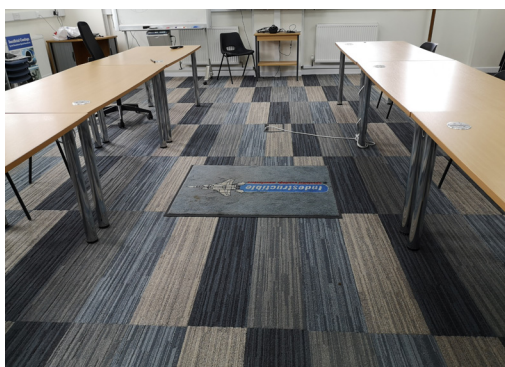


Photo 1: Carpet tiles in the office



Photo 2: Plastic board on partition walls



Photo 3: Stainless steel kitchen units



Photo 4: Standalone tables in the kitchen

All electrical points have been raised above 1.2 metres (see Photo 5), and the associated cabling now comes down from the ceiling. Computer screens are adjustable on a pole so they can be moved up flooding events (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 metres (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

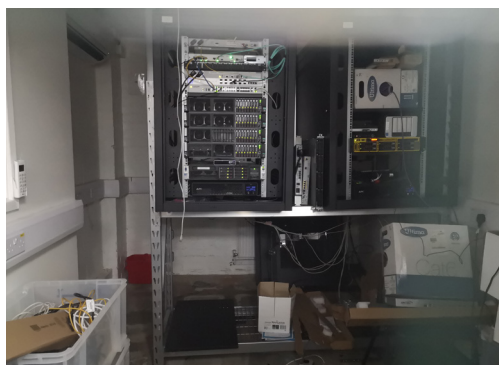


Photo 8: Servers on raised shelf



Photos 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 it needed 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. It now monitors the debris on the river and surrounding areas so it can report to the Environment Agency and the council to reduce flood risk to the local community.

The company also participates in local flood forums, although the local council's focus seems to be mainly on residential properties and it pays less attention to the needs of commercial properties. A significant amount of resource has been invested to protect its business but it is unable to get support and/or funding from the government (e.g. local council and the Environment Agency), which is disappointing and frustrating.

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 are no government or alternative databases that can provide useful information of practical flood resilience practices. What this company has done is through its own ingenuity and resources.

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 six-storey business centre for office hire in the north of England (see Photos 11 and 12).

The river had burst its bank before but only affected the car park so the owner never thought about the risk of being flooded. It was flooded in 2007 for only the second time (the first was in the 19th century), and has not been flooded since, but there has been a couple of close calls.



Photos 11 /12: Business centre by the river

During the 2007 flood, the water in the river had been building up for days so occupiers 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 four 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. And all the intellectual properties had been protected.

But it took three 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 cost £26,000 to repair the damage.

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

“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, we had an improved reputation. We didn’t lose any tenants.”

Flood strategy

After the 2007 flood, it was realised that flood risk is real for their property, and a three-stage 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 make 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 2007, a defence wall was built along the river by the council (see Photos 13, 14 and 15), and it has held on a number of occasions since. Money was raised through a business improvement district scheme from the local businesses to which they contributed £5,000 along with their business rates, and the money raised was matched by the council and EU funding.



Photos 13/14/15: Flood defence wall along the river

The council set up a flood defence project group which meets 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

The building owner also invested in floodgates (see Photo 16 and 17) at a cost of £6,000, as well as some low-cost measures such as sealants, which provide very good value for money. The manager commented on the floodgates:

“Whenever we get an amber warning, they go up. So that people can see. It’s more a reassurance for our tenants. I’m all for our tenants’ peace of mind. And they feel safe there now.”

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



Photos 16/17: Floodgate

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

After becoming aware of significant fire risks after the 2007 flood, the power sockets have also been raised by 1m in the ground floor offices (see Photo 18).

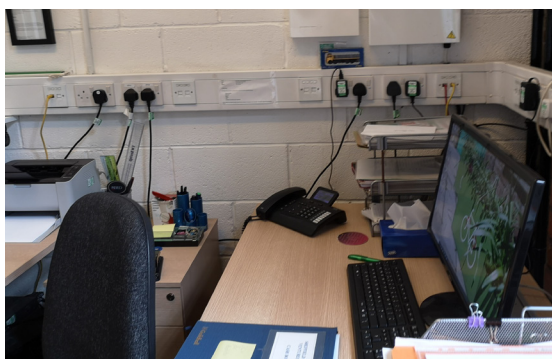


Photo 18: Raised electrical sockets in the ground floor office

Case No 3: Holiday cottage

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



Photo 19: Holiday cottage by the river

Insurance and recovery

During the flood, the water entered the ground floor and caused damage. The owner claimed £34,000 from the insurance company. Although the insurance premium has not increased by much, the excess amount has increased significantly (from £100 to £3,500). Recovery from the flood took nearly a year as everyone in the town wanted good tradesmen to do the repair work, so there was significant income loss.

Resilience measures taken

The kitchen units were completely ruined and were replaced. The replacement kitchen appliances, such as the cooker and fridge, are now portable (see Photo 20) so they can be moved to the upper floor during any future flood. The owner also raised the power sockets to a higher level (see Photo 21).



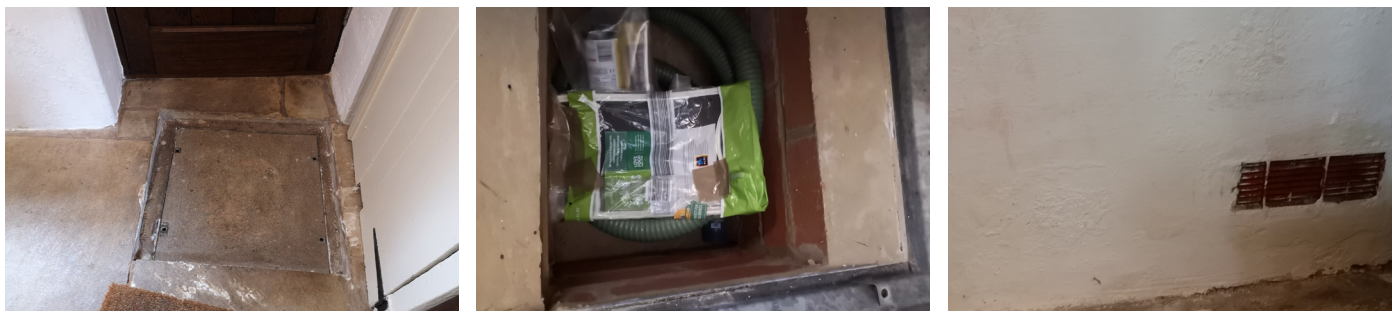
Photo 20: Portable kitchen appliances Photo 21: Raised power socket

During the repair, the plaster was stripped 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 22: Flat stone for floor

The owner also installed an electric pump (costing £500-£1,000) underneath the floor (see Photos 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.



Photos 23/24/25: Electric water pump at the entrance; the air vent

Asked why a floodgate had not been installed to prevent water coming in, the owner said they had considered it. But they were concerned it would put off future potential buyers because the cottage had been flooded and prone to flooding and this would devalue the property. Plus it does not look nice on the property.

That said, the owner believes that attitudes are changing, and flood measures such as a temporary floodgate may be a good thing as it shows the property is properly protected. Some companies can provide floodgates that look similar to the existing door so unlikely to affect the property aesthetically. The owner also mentioned that if you choose to live by a river, you should have the right mindset and be prepared for the possibility of flooding.

Support available

All the protection and resilience measures at this property are from life experience and observation of neighbours' practice. There is a local forum for flood information. The Environment Agency will send flood warnings by phone and text. It carried out an assessment after the flood and concluded it was not cost effective to have protection barriers along the river. The owner hopes the Environment Agency may do some work to slow down the flow of water from the hills with nature-based solutions, including not straightening the river and the use of farmland 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 many times in the past, and flooding has become more frequent, with the last in February 2021. The club has accepted that it must learn to live with water due to these more frequent flood events, the location of the property and the nature of the club. Flooding normally happens in winter, which is not the sailing season, so the interruption to the business is not as significant.



Photos 26/27: Sailing club by the river

Local community and support

The Environment Agency carried out an assessment of the village regarding the flood defence project, but concluded that such a project was neither viable nor effective. Instead, it offered £7,500 for individual property owners to work on flood-resilient measures themselves. The local council had offered some flood-resilience grants after the large flood events in 2015, which required a surveyor to assess and design according to individual properties. However, the sailing club missed out on that opportunity and had to fund the measures itself.

Resilience measures

To be able to monitor the flood situation remotely, a camera was installed in the property, and the club has registered for flood alerts/warnings with the Environment Agency. After the previous flood, the insurance premium for the property has not increased too much, probably because flooding is expected due to its location.

To prevent water entering the property, a floodgate has been installed at the main entrance (see Photo 28), which has proved effective. The club has also raised the power sockets above 1.2m (see Photo 29). And heavy and soft furniture has been moved upstairs and only simple and easy-to-clean tables, steel chairs and benches are left on the ground level, which has a hard floor to resist flood water (see Photos 30 and 31).



Photo 28: Flood gate at the main entrance



Photo 29: Raised electricity sockets



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

Raising the floor level was considered, but ruled out due to the ceiling height. However, the club plans to relay the floor so the water can be drained to one point, or a galley, to be pumped out more quickly. As it is an old building, the structure is not strong enough to resist the hydraulic pressure to resist water.

In the storage room, the petro tank is now raised so it will not be damaged and cause pollution in the event of a flood (see Photo 32). Shelves have also been raised in the storage room so valuable equipment can be placed above the water level or moved to the first 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 cement or waterproof paint would be considered for the external wall, the manager said the problem is when the cement plaster or waterproof paint gets old, it will crack and water will seep in and be trapped and damage the structure of the property. Instead, they will use a 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-storeys with a gym (see Photo 35), two squash courts, a bar, some offices and a boat house, plus 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



Photos 36/37: Marks of flood inside the building

Insurance

The property is insured, but the excess amount is high at £5,000 so it is not worth claiming for the damage if the flood is not too severe. The club members have helped with the cleaning-up work to reduce costs.

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 easy to wash and clean and within a week the club can operate normally. But if other parts of the building are flooded, it can take as long as two-to-three months to return to normality. Damage repairs would normally range from £1,000 to £4,000.

Resilience measures

After the 2007 flood, the bar was moved from the ground floor to the first so it is no longer at risk. The ground floor space is now used 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 was the wooden floor of the squash courts (see Photo 38). The side boards and tins had to be removed before the flood to allow the floor to partially float and the boards to swell without buckling (the floors expanded by an average 40mm during the flood), and dry the floor by using fans and radiators running 24/7 for days (see Photo 39).

The work cost £800 with volunteers from the club (which would have costed £12,000 at market prices). In the end, it took three-to-four months to restore the squash courts. The club has decided to raise the squash court floors to above the flood line, which is costly as it requires a new roof as well, but this will make them flood-proof, and the space below can be used as a gym.

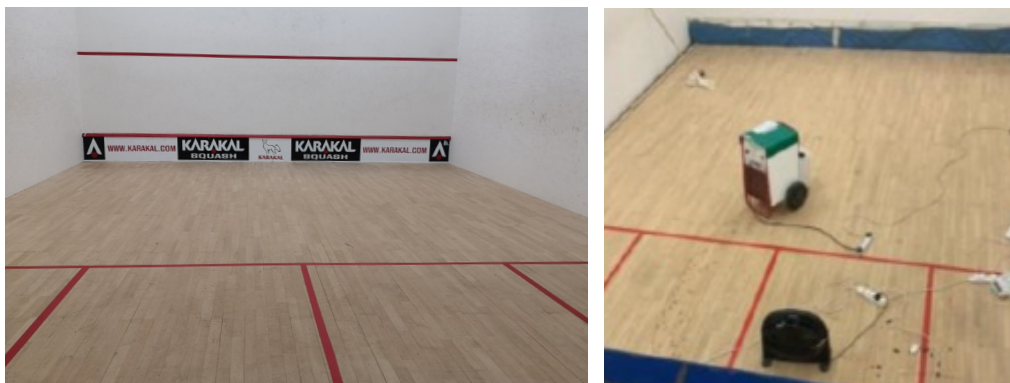


Photo 38: Squash court on the ground floor; Photo 39: Repairing the squash court after flood

A floodgate to prevent water coming into the building was considered, but it was deemed impractical as there are so many water entry points in the building, including the floors.

The club has a 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. In the event of flooding they need to predict the water level to decide whether to lift up the boats (which are expensive with each costing thousands) in the boat house (see Photo 40). They have to act early because the property is not accessible during flooding. In 2007, all the boats were moved off site as the water level was too high and they were at risk of damage from floating around.

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 switchboard and power are also put at higher level to reduce flood risk (see Photo 42).

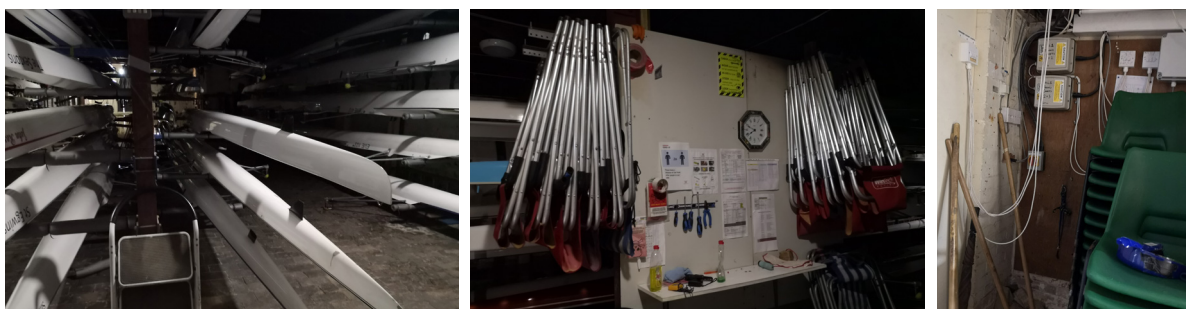


Photo 40, 41, 42: Rowing boats on shelves; Storage off the floor; Switch board and power high above floor

Case No 6: Touring theatre

Flood experience

This property belongs to a touring theatre company in the north of England. The ground floor has three 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 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 that had to be removed by the technicians from the manufacturer at a cost of about £170) to the rehearsal area. The floorboards and carpet had to be replaced.

A total of £11,700 was claimed from the insurance company and as a result, the insurance premium was increased. It took three-to-four weeks to resume normal business.

Local community and support

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

Resilience measures

After the 2015 flood and in order to choose the right level of protection and achieve the right cost benefit themselves, a consultancy was employed to carry out a risk assessment and recommend flood resilience measures. The theatre's management then raised some funds from their patrons to implement them.

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

"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 it as well, and affordable."



Photos 43/44: Electric pump under the floor in the office

They also installed floodgates at each of the external doors to keep water out during flooding (see Photos 45 and 46). They attached detailed instructions on the floodgate boards so anyone in the company can operate them (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 instructions Photo 48: Kits for flood

They have also installed an air vent (see Photo 49) and overflow pipe (see Photo 50) to release 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 particular 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 floods. From the case studies, there is a consensus that flooding will happen more frequently and more severely due to climate change, and we have to learn to live with water. This aligns with the principle of the National Flood and Coastal Erosion 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 flooding. Therefore, there is an urgent need to raise the awareness of flood risk among commercial property owners, especially those located in flood-prone areas, but who 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 forums, can play an important role in this. Local councils and the Environment Agency can also organise roadshows to publicise good practice for flood resilience, so that more businesses will appreciate the benefits of property flood resilience (PFR) measures to protect their businesses.

In the survey, nearly three-quarters of the respondents reported no increase

in their insurance premium after flooding, and this was also confirmed in the case studies. But excess amounts have increased 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 measures can effectively reduce and/or minimise damages from flooding. They will be particularly important to uninsurable properties as in Case No 1 because they could determine if a business can survive or not in an event of flood.

Flood risk protection measures

In the survey, the awareness of flood protection measures is evidently higher than of both resistant and resilient measures. According to the survey, the most popular protection measure is to move vulnerable/valuable items above the expected flood level. It is also the second most implemented protection measure. This measure is cost neutral and easy and quick to implement.

Not surprisingly, this measure was implemented by all the six properties in the case studies. But the challenge with this measure is that sometimes the flood occurs too quickly for people to move things in time, or the flood happens at an inconvenient time (e.g. a bank holiday weekend in Case No 1 and Christmas in Case No 5 and 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, while this measure may be simple and easy to implement, 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 flood resilience strategies into overall business risk management strategies, as in Case No 1.

Raising equipment and machinery on plinths is also a popular protection measure among the participants surveyed and 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 businesses can minimise the damage from the flood and resume operation much more quickly. 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 accurate, or comes in too late to give time to react, or comes at 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 flood forecasts will be improved significantly in the coming years (Sankaranarayanan et al, 2020).

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

Flood defence projects (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 in the form of business rates 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, such projects may not always be effective or viable and can also be overtopped (like Case No 3 and No 4). Therefore, businesses 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 with 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 changes to be made to the property, which may be more costly, but not very easy or convenient to implement.

Floodgates (door and window guards) are the flood-resistant measure people are most aware of and the most implemented in the survey. This measure also proved effective in keeping water out in the case studies (Case No 2, No 4 and No 6, see Photos 16, 17, 28, 45 and 46). Floodgates are relatively easy and cheap to install, use and maintain, with the added benefit that they give tenants and potential buyers the peace of mind and 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 floodgates may not always be effective if a property has multiple water entry points (e.g. Case No 5).

Airbricks and vents are the second most popular flood resistant measures and were implemented in Case No 3 and No 6 (see Photo 25 and 49). It is interesting to note that although waterproofing of external walls 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 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 levels is the measure respondents were most aware of and the most implemented in the survey. This is confirmed by most of the case studies (see Photo 7, 8, 18, 21 and 29). A closely related measure of moving gas and electric meters above the likely flood level is also relatively well received in the survey and the case studies (please see Photo 42).

These two measures are relatively easy to implement and can ensure the property becomes functional again quickly after the flood. This needs to become a standard practice in new-build projects to avoid the extra cost of retrofitting later. This can be achieved through updates to the building code and better education and training for designers.

The second most popular and third most implemented flood resilience measure in the survey is 'Replacing carpet floor finishings with floor tiles', as demonstrated in Case No 1 (see Photo 1). This measure has proved to be very effective as the (carpet) tiles can be washed and dried easily after flooding and put back.

And the third most popular and equally the most implemented flood resilience measure in the survey is 'Installing a concrete floor instead of timber floor'. In the case studies, property owners prefer hard floors, as shown in Cases No 3, 4 and 5 (see Photos 22, 30, 31 and 35). The benefit of hard floors is that they are easy to wash clean and can be returned back to use very quickly.

The squash court in Case No 5 (see Photos 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 cleaned easily and will save money and hassle in the event of a flood.

In all the case studies, except one (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 *Code of practice for property flood resilience* (Kelly et al, 2019) is

a welcome first step. 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 is manifested in different forms, including direct or indirect and tangible or intangible impacts, such as interruption to business, lost revenue, cost for recovery and increased insurance excesses. Businesses clearly have to take flood risk seriously and take action to minimise these impacts.
- 2.** Flood risk awareness is high among the participants of this study. This is probably due to the fact that the research targeted commercial properties located in flood-prone areas and the majority of the participants have experienced flooding. 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 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 for these events to mitigate the risks.
- 3.** A number of commercial properties have taken up PFR measures in a practical way to suit their business needs and these 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 resilience measures. However, resilience measures are often more permanent in nature and 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 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 range of benefits that can be attributed to PFR measures, which would better facilitate businesses' decision-making in investing in such measures.
- 5.** Many businesses lack sufficient knowledge of 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 consultancies 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 significant detrimental impact on businesses. Flood risk is real and increasing and 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-size-fits-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 business, companies are exposed to different flood risks. Individual businesses need to tailor their PFR measures to their specific conditions and business needs to achieve the maximum cost effectiveness.

3. Further research on the cost benefit analysis of PFR measures is needed.

To implement PFR measures, businesses must be able to justify their investment with their shareholders and they also have financial targets to meet. However, at present there is lack of information on the costs and benefits of different PFR measures, which affects businesses' decision-making on implementing PFR measures. Comprehensive research on the costs and benefits of different PFR measures will facilitate and encourage more of these measures in commercial properties.

4. A 'one-stop' hub for PFR measures is needed to provide the information businesses need.

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 waterproof external walls, can be easily incorporated into the design and construction of new commercial properties with no or little extra cost. This will save a lot of time and cost compared with retrofitting these measures later on. Commercial property owners should explicitly specify PFR measures in their project briefs from the outset of their capital investment.

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