

IMPROVING THE FLOOD RESILIENCE OF COMMERCIAL BUILDINGS THROUGH PROPERTY FLOOD RESILIENCE MEASURES

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ABSTRACT

The impacts of flooding on businesses include financial damages, business interruption, breakdown of supplies and ultimately business failure. While some commercial properties have developed a level of resilience through taking steps to protect and adapt their premises, the majority are vulnerable to these impacts and lack any level of resilience to flooding. The concept of property flood resilience (PFR) involves the application of a range of measures that can be applied to a property to make people and their property less vulnerable to the impacts of flooding. While this approach has been the subject of much research, leading to an acceptance of this approach in UK flood risk policy and strategy, there has been a dearth of research on the use of PFR for commercial properties. The aim of this research is to explore the application of PFR to commercial properties, and to develop insights into their current usage as well as the potential application in the future. This research draws on a critical examination of the existing literature to reveal the full extent of the impacts of flooding on commercial properties. These impacts are classified as direct/indirect and tangible/intangible impacts, while mitigation measures are found to consist of a hierarchy based on avoidance, resistance, reliance and reparability. Further research is recommended on how to improve the flood resilience of commercial properties through property level measures.

Keywords: commercial property, property flood resilience, flood impact, mitigation measures, adaptation measures.

1 INTRODUCTION

Flood 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 [1]. 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 [2]. 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. An analysis of global statistics conducted by Jonkman [3] revealed that floods had caused 175,000 fatalities and affected more than 2.2 billion people between 1975 and 2002.

Similarly, the impacts 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 [4]. 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, rivers, surface water, groundwater and sewers flooding [5]. The coastal profile, areas within 10 km of the coast, is occupied by around 10 million people which accounts for 40% of the manufacturing industry [5]. 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. This is with the exclusion of the effects of estimated population growth which is also a key variable to increasing flood risk [6].



Much research has been done on flood risk, with respect to its impacts, mitigation approaches and decisions about minimising future impacts. However, most of the research carried out on buildings has concentrated almost exclusively on residential properties. There exists a dearth of research about the impacts of flooding on commercial property [7]. It is estimated that around 185,000 commercial properties are at a direct risk of being affected by flooding [8]. The statistics on the 2007 floods laid emphasis on the havoc flood 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 [7]. In the 2015–2016 winter flood event, an estimate for business property damages is £513 million with a range of £410 and £616 million paid out by the insurance industry as business claims [9]. 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 [7].

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 [10]. For instance, according to the Property Data Report in 2013, in the UK, the market value of the core commercial properties, such as the retail, office, hotels and industrial properties was £683 billion [11]. Commercial property also represents a major investment asset for both the pensions and insurance industries [12]. 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 £3,200 billion and employing about 22.8 million people with an average growth rate of 2.2% since 2008 [13].

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 [7]. 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.

As means of mitigating these impacts, innovative approaches have been developed [14]. One of such is structural measures which are engineered solutions designed with defined limits of disturbance they can accommodate [15]. Once the disturbance produced is more than the specified threshold capacity of the engineered solutions, defences can be overtopped and lives and properties again become susceptible. The presence of these structural measures offers some amount of resilience to flooding, it is however very difficult to sustain and mostly overwhelmed by the next greater flood event. Despite the huge investment in structural approaches and engineering measures, flooding still 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 [16]. This approach, in the context of property level flood risk, often entails building resilience into the system that is exposed to the risk. For properties, much attention has been focused towards the development and adaptation to the risk of flooding [17], [18]. This concept is commonly referred to as property level flood resilience or property flood resilience (PFR) and has, since its inception, gained wider recognition in the domain of flood risk management [14], [19].

This research draws on an examination of the literature to analyse the impacts of flooding and flood risk on commercial properties. The concept of property level flood risk mitigation is then discussed with a focus on the recoverability/resilience measures appropriate for



commercial properties. The study ends with some recommendations for further research towards helping to establish this approach more widely.

2 FLOOD IMPACTS ON COMMERCIAL PROPERTIES

Loss and damage from the flooding of commercial properties is evident globally and seen to be prevalent in the UK [20]. Damage caused is greatly associated with the continuous interaction between the natural and human systems [21]. Flood damages, whether potential or actual, have been classified as either direct tangible, direct intangible, indirect tangible, or indirect intangible damage [22], as summarised in Table 1.

Table 1: Classification of flood impacts on commercial properties [22].

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 [20]. 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 [20]. 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 [23], [24].

2.1 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 [25], [26]. 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 [27], 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 [26]. Lost documents and records are vital physical losses and often considered intangible impacts, which can delay post event recovery work.



2.2 Indirect impacts to commercial property

Indirect damage is induced by flooding, but occurs, in space or time, outside the actual event [28]. 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 [29]–[31]. 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 [30]. 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 [28].

One component that can be affected by both the direct and indirect impacts is the value of commercial property. According to the RICS [32], 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.

3 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 [33]. The little evidence available is often subjective in nature and mostly concerning small and medium enterprises [33]. 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 [34] 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 [35]. 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 [36].

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 [34]. These are summarised as follows:

- i. 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.



- ii. Resistance: comprises of measures that are taken to prevent floodwater from entering into the building and damaging its fabric and contents.
- iii. 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.
- iv. 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 into 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		√

3.1 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 600 mm) [34]. Consequently, this approach is often adopted up to a threshold value of 600 mm around a property, although in some cases surveyors may recommend this to be conducted up to 300 mm [37]. 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. In order 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 into the building, meaning that the resistance approach fails. Work has been done to identify these potential points of water entry mainly in residential building [37], [38] 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 [39]. 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 [37]. However, one of the disadvantages is that the stability of the building structure can be jeopardized because of the heavier load of flood water [39].

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) [35]. However, it is recommended that above the 600 mm threshold height, a resilience approach should be adopted [34].

3.2 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 [34], 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 [39]. 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 [39]. 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 [38]. 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 [37]. 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 [36].

According to the Dhonau and Rose [36], the following measures should be considered in making a commercial property resilient:

- i. raising electrical sockets, electrical wiring and controls for ventilation systems;
- ii. raising equipment and machinery on plinths;
- iii. using materials that can withstand flooding, for floors and the lower part of walls and staircases;
- iv. backing up customers' data on a regular basis;
- v. storing customers' files and supplier contracts safely;
- vi. keeping insurance policy in a secure, accessible place, as well as a copy in a "Grab bag" or "Battle box";
- vii. 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 [40].

4 MOVING FORWARD

The existing literature shows that much of the research on property flood resilience (PFR) has been directed towards residential properties. Meanwhile, commercial properties represent an important component of the built environment, and very often the economic and social impact of flooding are far greater on commercial properties. There is a pressing need to investigate the application of property flood resilience (PFR) measures in the context of commercial property.

Supported by the RICS Research Trust, this on-going research project aims to investigate the application of property flood resilience (PFR) to commercial buildings. A survey of a range of commercial property owners (e.g. office, retail and industrial) located in flood prone locations is to be undertaken to examine their flood history and experience, recovery process, the availability of suitable technical interventions and, importantly, the views of the key stakeholders. The findings from this research will help to inform future flood risk policy towards the protection of commercial properties. It would also provide useful guidance to commercial property owners on how to improve their flood resilience.

This research is anticipated to produce some practical recommendations in the form of an RICS Guidance Note for commercial/general practice/building surveyors on how to implement PFR measures in commercial buildings. This will facilitate the provision of



professional advice to commercial property owners and support decision making, property valuation, investment, insurance and flood risk management. The findings will be of interest and use to surveyors in all world regions. The research findings will also provide evidence-based information to inform future flood risk policy and strategy, particularly Defra and the Environment Agency. Although this research will use data from commercial properties located in the UK, the findings and recommendations are likely to be applicable to other regions and countries. The findings could be used for the basis of future research to take account of regional variations and local methods of construction.

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