E3S Web of Conferences 7, 22002 (2016) DOI: 10.1051/e3sconf/20160722002
FLOOD*risk* 2016 - 3rd European Conference on Flood Risk Management

Property flood resilience database: an innovative response for the insurance market

Stephen Garvin[1,a], Katy Hunter[1], Dermot McNally[2], Douglas Barnett[3], Rob Dakin[3]

[1]*Building Research Establishment, Orion House, East Kilbride, G75 0RD, UK*
[2]*Lexis Nexis, D'Olier Street, Dublin, Ireland*
[3]*AXA Insurance, Mark Lane, London, UK*

Abstract. The property flood resilience database (PFR-d) has been created through a research feasibility study undertaken by the Building Research Establishment, AXA Insurance and Lexis Nexis Risk Solutions in the UK. The project was funded by Innovate-UK and was undertaken over the period of May 2014 to August 2015. There has been a growing realisation that flood management has to move from a position where flood defence (e.g. major river barriers and drainage infrastructure) is the only solution to flood risk to one of flood resilience. This shift requires an increase in responsibility for a variety of stakeholders, including property owners. The PFR-d was conceived as a product that code fit within the existing insurance frameworks and systems. The PFR-d is a 'missing piece of data' for insurers that could assist in providing more appropriate insurance pricing in high flood risk areas, or where properties have suffered repeat flooding events.

1 Introduction

Flooding can have devastating consequences for a community, leaving people out of their homes with lost possessions, and businesses closed or seriously disrupted. In the floods of the winter of 2015/16 over 16,000 properties were flooded over a period of one month in different areas of the United Kingdom (1). It is something no one wants to happen to their community. There are, however, property measures that can lessen and remove the impact of flooding.

Such measures have been promoted through government sponsored schemes, protecting homes either on a permanent or temporary basis, and those carried out by the home owner to protect their property from flood damage. For both parties, it is important that the financial and technical work that they have done is recognised, in particular by the insurance sector when it comes to obtaining insurance and the cost for such insurance. In the UK there are over 6 million properties at risk of flooding from various sources (river, coastal, pluvial and groundwater) of which many are at significant risk (2). In recent years there have been an estimated 20,000 properties typically in high risk areas, which are now protected by property level protection measures.

Insurance companies today in the UK use sophisticated systems to geocode (map) a property location to a high degree of spatial accuracy (within a metre) and assess the level of flood risk by overlaying the location on predictive models. Such flood models use datasets such as elevation, land use, rainfall, river geometry, river flow rates and tidal data to predict depths of flood water for particular sized events (1:75 years, 1:200 years etc.). Using such information, the insurer will assess the level of risk and in return the premium or even the desire to underwrite the property will be determined. This has significantly improved on methods used years ago where whole towns could be 'black listed' as the science and technology wasn't available to undertake mapping and modelling at a building level.

The flood protection work being carried out by the government, city councils, local authorities and property owners needs to be aggregated and in a format that the systems used by the insurers can readily digested and used. Not only that but there needs to be common standards applied to the work being carried out so that the insurance market can automatically use the standard information as a guide to the level of resilience applied and therefore the levels of associated flood risk.

A research project undertaken by Building Research Establishment (BRE), AXA Insurance UK and Lexis Nexis involved a feasibility study funded by Innovate-UK had the aim to develop a Property Flood Resilience Database (PFR-d), which combines the environmental datasets on flood risk with resilience measures undertaken.

The project was required as the PFR-d is a 'missing piece of data' for insurers that could assist in providing more appropriate insurance pricing in high flood risk areas, or where properties have suffered repeat flooding events. The existing datasets used by the insurance sector provide flood risk information in the form of maps and exposure zones used to assess potential flood risk (depth

[a] Corresponding author: stephen.garvin@bre.co.uk

and return period) in the future. What the insurance industry is currently not able to take into account is the investment made by the insured and the government on protecting properties through implementing flood resilience. The project has been undertaken to develop a prototype, involving the gathering and scoring of information on Property Level Protection and resilience of buildings. It has developed a framework for the PFR-d (combining existing datasets with the new PFR-d) and has piloted the process through a trial area in the UK.

2 Flood resilience measures

Flood resilience measures at property level are encompassed within two particular approaches, as follows (3, 4):

- Dry-proofing or resistance: Water is prevented from entering the property or penetrating into the structure by sealing the building or by using flood protection products.
- Wet-proofing or resilience: Water is allowed to enter the building but the building fabric and the contents are 'waterproofed' by application of flood-resilient materials.

Flood resilience is the ability of property to cope with flooding and the ability to recover from flooding. This is a term generally used in the UK. This strategy is in line with dry-proofing and wet-proofing, terms which are used in other European countries.

Flood resilience technologies provide resistance or resilience to flooding. Different types of technologies are available and are described in this section.

2.1 Resistance

Aperture technologies are property-level protection barriers, designed to prevent the ingress of flood water into a building by protecting the openings such as windows, doors and air bricks. The specific technologies could include:

- air brick covers
- door guards
- building-fixed flood guards
- non-return valves.

Building aperture products, used for all openings within a building, could combine to create a flood-resistant system for the property. A flood-resistant system will only be achieved if the householder or other nominated person has sufficient warning of the impending flood and is capable of mounting the barriers when they are required.

Innovation in this area has resulted in the availability of a range of flood doors, flood windows, self-closing vents and automatically operated air bricks. If flood water is present for more than a few hours, it may begin to seep through the walls.

To develop a flood resistant system for the whole building, the application of waterproofing materials to the walls may be necessary. Flood-resistant materials used for building aperture technologies are generally metals or plastics which are durable and have low water permeability. The joints between barrier sections and between the barrier and the aperture are the weakest points and as such, special care should be taken to ensure that a tight seal is achieved.

Many companies offer standard-size barriers for doors and garage doors, windows and air bricks, but specialist sizes can often be manufactured for bespoke openings.

Construction

During the construction phase, permanent framework or supports of aperture barriers should be fully fixed and sealed to the receiving building. Permanently installed technologies, such as automatic air bricks, or non-return valves for plumbing systems, will also be installed in this phase.

In the event of a flood warning, the temporary or demountable FRe technology parts must be installed. This will include door boards which are attached to fixed rails, barrier sections which are slotted into fixed supports and demountable air brick covers.

2.2 Resilience

Wet-proofing and resilient materials are used to create a resilient system which will reduce flood vulnerability and will be more easily returned to its original state after a flood event, as cleaning and drying times are greatly reduced and necessary repair work is minimised.

An innovative flood resilient property design, The Flood Resilient Property (5), two wall to floor options were considered. Option A includes a primary and secondary layer of waterproofing: water tanking below slab to resist water pressure and cavity drainage for water collection after flood. Option B proposes water proof concrete in place of a water proof membrane: concrete slab and wall with water resistant additive, full cavity waterproof insulation and cavity drainage for water collection after flood.

Internal masonry walls and partitions have good resilience to floodwater but the plaster and plasterboard finishes may deteriorate. Timber and steel-frame partitions are generally clad with plasterboard, although earlier examples may be fibreboard. There is a risk of water leakage into the partitions which could cause rotting and corrosion. Gypsum plaster should be replaced on masonry walls with hydrated cement:lime or hydraulic lime:sand based equivalents. Gypsum plasterboard could be replaced on masonry partitions with resilient plasters (as for the inner leaf of external masonry walls). Alternatively, cement-based boards should be used. Hanging plasterboard horizontally rather than vertically should be considered.

Wet-applied plaster in not an option for frame construction - plasterboard should be used as for masonry partitions. The junctions between walls and partitions and floors should be sealed with good-quality sealants. Mineral wool insulation in internal partitions should be replaced with closed-cell type insulation. Damaged timber should be replaced with treated timber and corroded steel frame members with galvanised steel equivalents.

Ground-floor construction usually falls into one of two categories: solid or suspended. Solid floors are likely to consist of concrete, insulation, damp-proof membranes, screeds and finishes. Suspended floors can be formed from timber or concrete (usually beams infilled with concrete or concrete blocks). Floating floors have become more common in recent years and involve timber decking or screed being places on insulation and then a concrete base. They are used for both solid concrete and suspended concrete floors. Water ingress into such floating floors can be difficult to repair. Upper-storey floors are generally not at risk from flooding but they can be affected by secondary effects e.g. arising from condensation and mould. DCLG (3) state that the behaviour of ground floors in floods can be influenced by two different conditions: water ingress from the ground and exposure to standing water. These can occur simultaneously. Water ingress from the ground is potentially more severe and is more likely to affect the structural integrity of the flood (3).

Other floor issues, not covered in 3, are associated with damp-proof courses and membranes, insulation and finishes:

- Damp proof-courses in membranes need to be checked, any damage identified and repaired. It should be noted that it can be difficult in the short term to differentiate water penetrating the screed or slab from below, from absorbed floodwaters that are drying out. This makes the membrane damage hard to identify.
- Water will affect some types of insulation. Where, insulation has been damaged or contaminated, it should be replaced with a closed-cell rigid board type. If the insulation is wet, but not damaged or contaminated, it might be retained and thoroughly dried out.
- Floors will almost inevitably be wetted, often for a long period of time. Floor finishes should be considered with regards to their resilience to flood as well as the ability to seal the floor against floodwater.

Short-duration flooding is unlikely to cause damage to particular types of door or window, however floodwater can breach the seals of the doors and windows and additional protection will be required. Material consideration is also important. For example, prolonged contact with floodwater can cause wooden external doors to swell; they can also warp or split when drying. Furthermore, collapse of the internal structure or rotting from the inside can occur as a result of water entering the inside internal doors with hardboard and MDF skins. Floodwater can also lead to corrosion of internal metalwork and high depths of flooding can put pressure on seals and damage them (6).

The resilience of services is particularly important, as provision of water, fuel and power are essential to the use of the building (during and) after a flood has occurred. Electrical services have little resistance to floodwater and are easily damaged; they may need to be replaced, or thoroughly dried and checked for safety before reuse. Other services have greater resilience – water and drains may only require inspection and repair to make sure they continue to work without the floodwater backing up. The repair standards have been outlined in Table 1.

Fittings include domestic appliances (white goods), furniture, units and similar items. Their flood resilience varies greatly depending on the product type and the materials involved. White goods are electrical therefore they are at risk of damage as well as contamination. Exposure to floodwater can cause significant damage to kitchen and bathroom units and furniture based on chipboard. Solid timber or plastic units are less likely to be seriously affected.

Electrical	**1.** Electrical services should be placed within easily accessible conduits and voids so that they can be drained, checked and fully dried. Such conduits could include replacement skirting boards in PVC-U that are sealed to the walls and floors.
	2. Alternatively, move electrics to a higher level in the structure so that power cables drop from first-floor level down to the sockets, position at least 1 m above floor level.
	3. The electrical cables will normally be accommodated in channels or voids in the wall. Where different wall finished abut, such as a change from plasterboard to plaster, the accommodation of electrical cables and sockets must be taken into account.
Gas	**1.** Gas fittings should be checked for leaks.
	2. Replace damaged copper pipes with similar ones and wrap them in protective sleeving.
Oil	**1.** Raise the oil tank above the ground-floor level (above the likely flood level if possible) to avoid the risk of water entering the tank. If the tank cannot be moved it should be secured so that it does not float in floodwater.
	2. Remove boilers from the ground floor, mount boilers on to the wall 1 m above floor level or on a plinth above the level of a flood.
Water	**1.** Wrap water services in polyethylene to seal them fully, this will prevent the floodwater ingress
	2. Place water service pipes in conduits or voids through floors or walls to make them easily accessible for inspection.
	3. Protect taps using non-return valves.
Drainage	**1.** Rubber test plugs or inflatable plugs can be fitted into the ends of exposed pipes (fit after a flood warning has been issued).
	2. One-way valves can also be used.
Meters	**1.** Move metres to at least 1 m above floor level.

Table 1: Resilience measures for services after Garvin (7)

Basements are usually designed to resist the ingress of groundwater through the use of tanking to waterproof the structure. However, where the flood level rises above the top of the tanking, water can enter the basement. The standards of repair concentrate on the removal of water using pumps. In particular, sump and pump techniques could be usefully incorporated into an existing building to achieve greater resilience. The costs involved are significant but the maintenance costs can be considered low (Garvin et al. 2005). Repair options for walls and floors can be followed as described in previous sections.

2.3 Community measures

There are a range of community measures that are used in order to protect groups of properties. These measures are variable, they can be classified as perimeter barriers that are used to divert flood water away from property, sustainable drainage that can help to manage surface water in urban areas and flood management activities such as warning systems and organised local flood groups.

2.3.1 Perimeter barriers

Perimeter barriers are installed along or around developed areas to protect them from flood actions. For example, the barriers can be used to prevent flood water from approaching a building (or group of buildings) located by a river or the coast, or to divert flood water to a storage area.

Perimeter technologies can be temporary, demountable or permanent, but all are designed to protect a building, series of buildings or critical infrastructure during a flood event. These products operate by fully surrounding and separating the area from the source of flood risk to create a resistant barrier. Its effectiveness will depend on whether it is activated or installed in sufficient time. The amount of warning time, and hence installation time, will be governed by the type of flood and the location to be protected.

Perimeter barriers are also able to protect at community level. A local authority or local champions group may be best placed to coordinate and organise efforts to implement a community perimeter system. Its successful implementation is often dependent on flood warning systems, and the time and resources available for installation.

Materials that are not susceptible to the ingress of water (e.g. metals and plastics) should be used for perimeter barriers. Special care should be taken when designing and specifying materials for the joints between sections of the barrier as these joints will be the weakest points in the barrier. A plastic seal is usually specified for this reason. Careful workmanship is required to ensure a tight seal.

As for aperture barriers the construction stage should be carried out in accordance with good practice. The steps to be taken for initial construction include:

- setting out
- preparing the ground or building area to receive the permanent parts of the FRe technology
- building in the permanent parts.

The entire barrier should then be installed and tested to check the product's watertightness. When the construction phase of the installation has been carried out, a second flood risk mitigation survey should be undertaken to identify:

- the level of residual risk and any additional measures that might be needed
- the operational conditions required for the successful use of the FRe technologies (eg access from transport routes and deployment time).

Often, the construction stage installation of aperture and perimeter barriers will be undertaken by the manufacturers. If this is not the case, then the installation contractor should liaise with the manufacturer and consider all points in the surveyor's report.

Demountable and temporary parts of FRe products will be installed during the operational installation stage in the event of a flood, or a flood warning. The operational stage has been identified as having four phases.

- Logistics: suitable storage areas, transportation of products, and training and availability of personnel
- Flood plan development: management and mobilisation plan to ensure technologies are correctly deployed in the event of a flood
- Operation: installation of the flood protection
- Post-event: barrier removal and cleaning, site clearance, waste removal.

2.3.2 Sustainable drainage

Sustainable drainage is a departure from the traditional piped approach to draining sites (8). Sustainable Drainage Systems (SUDS) mimic natural drainage through:

- storing run-off rainwater and releasing it slowly (attenuation)
- allowing water to soak into the ground (infiltration)
- slowly transporting (conveying) water on the surface
- filtering out pollutants
- allowing sediments to settle out by controlling the flow of the water.

Soakaways are one of the key technologies for SUDS. They enable stormwater to be dealt with at source rather than being diverted directly into the sewer system, and satisfy the criteria listed in the bullet points above. Soakaways can be used on their own or as part of a larger SUDS development. Considering SUDS at the earliest stages of site selection and design makes it easier to integrate them into developments. SUDS can influence other aspects of the site (ie design, layout, function). Reducing impermeable areas wherever possible is also important.

A useful concept used in the development of SUDS is the SUDS management train. Drainage techniques can be used in series to change the flow and quality characteristics of the run-off in stages.

Recent guidance in the UK (9) states that drainage systems should be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur on any part of the site for a 1 in 30-year rainfall event. The drainage system should be designed so that, unless an area is designated to hold and/or convey water as part of the design, flooding does not occur during a 1- in 100-year rainfall event in any part of:

- a building (including a basement)
- or in any utility plant susceptible to water (e.g. pumping station, electricity substation) within the development.

2.3.3 Flood management

There are a number local flood management measures that can contribute to the resilience of communities and property. Of these credit can particularly be given to flood warning systems and to local flood groups and forums that initiate actions in flood events.

Flood warning systems in the UK typically cover those areas where there is a risk of river or coastal flooding. Individuals can sign up to the flood warnings, which are provided by the various environment agencies in the UK. This is particularly important where it is necessary to install items of technology to protect the building. The level of flood warning given will vary, initially a lower level may not require action by property owners, but once the higher risk is encountered then action must be taken.

Local flood groups are important with regards to preparing communities for flooding, which can include advice on the most appropriate measures for the particular type of building and the flood risk. The local flood group can ensure that once warnings are received that property owners take the necessary measures. Indeed a well organised group may be able to cover an individual property where the owner is absent for a period of time.

3 The database

This section of the paper describes the Property Flood Resilience Database (PFR-d), in particular the approach, how the data is gathered, scoring and integration with insurers systems.

3.1 Approach

The project team initially created a prototype design for the PFR-d. This involved determining the main 'headings' that should be considered. This resulted in the following main categories:

- Resistance
- Resilience
- Community.

Within each category are a number of factors, for which a sub-factor should be selected. The sub-factors are selected depending on the construction of the property, the automation of measures, certification of products and on-site testing.

In terms of a flood risk management strategy, the approach adopted should consider the depth of the expected flood. To ensure a safe and simple design the following guidelines (3) have been followed:

- Depths less than 0.3 m Flood resistance
- Depths between 0.3 m Flood resistance and 0.6 m (unless structural safety concerns exist)
- Depths above 0.6 m Flood resilience.

The resistance measures in particular contain a range of measures for which proprietary products are available. For example the external ground floor doors to property are a key point where water ingress might occur. The options are to either cover the doors with external boards or guards, or to replace the existing doors with specially manufactured flood doors. Additional recognition is made where the products used have been suitably tested and approved (preferably through a recognised third party certification scheme). Additional credit is also given where the installed product has been site tested.

For resilience the approach is based upon the measures taken. For example a solid concrete floor with sealed resilient finishes will be given more credit than a suspended timber floor even if the floor finish is resilient.

Resilient cavity wall insulation is determined by the extent of fill in the cavity and the type. Mineral wool batts and blown-in fill are given no credit due to the amount of time required to dry the material, and the potential for slumping when wet. Injection plastic materials with closed cell structure and low absorption are given the most credit.

For community measures the various options on community perimeter barriers result in the greatest variation in factors. Greater credit is given where the technology and product used have been tested and certified. Self-closing barriers, which are permanently in place, gain greater credit than those that need to be put into place in the event of a flood, for example temporary and demountable types.

3.2 Building survey, data and completion of work

In order to populate the PFR-d it is necessary to undertake a building survey. Property resilience measures may be installed as part of a repair to a flooded property or at any time that work is scheduled. The 'six steps' guidance that resulted from the FP7 project SMARTeST (10) provides a useful procedural guidance to follow, involving the assessment of risk through to maintenance of resilience measures.

The uploading of property data to the PFR-d will be undertaken only by certified surveyors. A survey of the property will allow basic property information to be uploaded. The resilience measures can then be designed and implemented. On completion the surveyor uses an app that can be run on a mobile device, tablet or PC to input all measures taken and allow the final measures to be lodged and stored on the PFR-d.

3.3 Scoring

At present the risk profile of a property is determined based on the nature of the flood risk faced and the depth of the flooding. The risk score is also informed by the likelihood of a flood occurring based upon an annual probability. A number of different scoring mechanisms are available, with values either given as percentages or on a scale of, for example, 0 to 30.

In order to complement the existing approaches taken to flood risk assessment the project team investigated an approach to scoring the measures taken by adapting the flood risk score for the property. However, in consultation with an expert steering group it was decided that a better approach was to have a separate score for the property to sit alongside the flood risk score. This Property Flood Resilience Score (PFR-s) would inform the homeowner and other stakeholders such as insurers on the resilience of the property.

In order to derive the PFR-s an algorithm has been developed that uses the various resistance, resilience and community factors that have been implemented at the property and produces the score. The PFR-d will contain full details on building and measures taken, which may be specific to resistance, resilience or community, or indeed a combination of two or three. If the approach taken is resistance only then it is necessary to completely protect all points of water entry in the ground floor of the building. Failure to do so will result in the PFR-s being no better than a property without any measures.

The entry on the PFR-d will require to be refreshed at an appropriate point in time. At present a three year cycle of checking by the surveyors that the measures are still in place and have been appropriately maintained is required.

3.4 Insurance systems

The PFR-d links to insurers systems to not only assess flood risk to a property, but to allow data on the property itself and the interventions made to part of the assessment process. Individual insurers can use the measures taken, summarised into the PFR-s, to determine whether or not they will offer insurance to the property and indeed the premium and excess to be offered.

For homeowners the benefits of being on the database are that they may be able to receive greater choice of insurance premiums at an affordable level. The greater the investment that a homeowner makes then the better the score received and ultimately the better is their return through insurance.

4 Conclusions

The Property Flood Resilience Database is an innovation that can provide assistance to a number of stakeholders. In particular, the key beneficiaries for the PFR-d will be property owners, who stand to benefit from access to a greater range of insurance options, as well as more affordable insurance.

The insurance industry itself will form the main client base. The PFR-d offers the opportunity to provide data directly to the market with regards to the resilience measures that have been taken. The scoring mechanism (PFR-score) will give the opportunity to assess different resilience options and to allow the value of different interventions to be addressed.

The PFR-d has the potential to encourage greater take up of quality assessed and certified products by providing them with greater benefit under the scoring mechanism. The PFR-d can act as a driver to improving the market.

5 References

1. Association of British Insurers (2016). New figures reveal scale of insurance response after recent floods. https://www.abi.org.uk.
2. The Environment Agency (2009). Flooding in England: A National Assessment of Flood Risk. Bristol, UK.
3. Department of Communities and Local Government (2007). Improving the Flood Performance of New Buildings - flood Resilient Construction Guidance. London.
4. Garvin S and Hunter K (2014). Flood resilient technologies, BRE Good Building Guide GBG 84, IHS Press, London.
5. Garvin S, Hunter K, Barker R, Pellizzon R, Alexander J and George G (2014). Flood Resilient Property. Report to Defra, UK.
6. British Standards Institution (2015). BS85500: Flood resistant and resilient construction. Guide to improving the flood performance of buildings. BSI, London.
7. Garvin S et al (2005). Standard for repair of buildings following flooding, CIRIA Publication C623, London, UK.
8. Garvin S (2016) BRE Digest 365. Soakaway design, IHS Press, London.
9. Environment Agency. Sustainable drainage systems (SUDS) A guide for developers.
10. Connelly A, et al (2013). Six steps to property level flood resilience, Guidance for property owners / guidance for professionals, see www.smartfloodprotection.org.

6. Acknowledgements

The authors would like to express thanks to Innovate-UK for their support of the project through Grant Number 36726-270252.