Novel solutions to a traditional method of property-level flood protection: technical insights into innovative door aperture guards

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Abstract

This study provides technical solutions to issues surrounding existing types of commercially available door aperture guards used to provide external protection to buildings from floodwaters. Newly designed door aperture guards (Patent Pending GB1401368.4 and GB1404806.0) offer several practical advantages over those of existing designs and systems. The first type of barrier (GB1401368.4), which is for a step or low profile sill, is easy to deploy and is the first barrier to compress the vulnerable barrier bottom seal to ensure a watertight fit. The second type of barrier (GB1404806.0), which is for UPVC door sets, uses resin anchors to hold a rigid frame that spans the brickwork below damp proof course and brick reveals; thereby, strengthening the at risk aperture reveals, whilst also protecting any weep holes that are located beneath the sill. Both of these barriers have fixings that are hardly visible and, as such, they offer the added advantage for being suitable for use in conservation areas. Furthermore, as there appears to be no current flood door with a low profile threshold, the new door aperture guards are the sole answer for door sets used to provide the necessary accessibility for disabled persons. Whilst door aperture guards remain the only affordable flood resistance solution for many homeowners, to make these products available to flood victims it is necessary they are first tested to BSI kite mark accreditation (PAS 1188-1: 2009).

Keywords: flood resistance, property protection, door barrier, patent product.
1 Introduction

The threat of flooding affects nearly two million homes and ~10% of the UK population [1]. The UK Government predicts these figures will increase as a direct result of climate change. In the face of such predictions and now finding itself unable to increase spending on community flood protection schemes, the UK Government has effectively passed down the responsibility to homeowners who must install flood protection measures to protect their properties from flood damage [2].

One of the major routes of floodwater ingress into buildings is through the gaps and seals around doorways. Therefore, there has been a great deal of commercial development on door aperture guards. Typically, this is a waterproof board with perimeter seal that is temporarily fitted across a doorway to prevent floodwater from entering a property during a flood event. Deployment of door aperture guards by the homeowner remains a cost effective solution. Furthermore, it is often essential where UK Building Regulations, Part M, disabled access requirements result in low profile thresholds that cannot be sealed by any current flood door designs [3].

There are generally two types of external doorways that need flood protection. These are: a door frame with a stone step or low profile threshold; and a more modern UPVC type doorframe with bottom frame member, and UPVC sill affixed. Current ranges of door aperture guards have many inherent problems. Some need perimeter channel section frames that are permanently fixed around the doorway [4]. Personal conversations with homeowners reveal they find permanent channels are upsetting as they serve as a constant reminder to them of the possibility of a flooded home and a source for visitors to their home remark upon. Some existing door aperture guards feature permanently fixed channels and they may also be heavy and difficult to carry and manoeuvre into position [5, 6]. Some designs use adjustable clips that are time consuming to deploy around the door frame. Similarly, others use multiple bolts around their perimeter to sandwich layers together and again may be difficult and time consuming to deploy in a flood event [7]. The type of door aperture guard that needs no channels fitted to the sides of the doorway and bolts to the outside face of the doorframe is, therefore, far more acceptable to the homeowner [8], particularly where a threaded insert can be set into a timber or UPVC doorframe to accept the door aperture guard mounting bolts, these inserts are practically invisible.

This study proffers solutions to these problems by detailing technical insights of two new door aperture guard designs.

2 Novel solutions to overcome the problems of traditional door aperture flood guards

Two new door aperture guard designs (Patent Pending GB1401368.4 and GB1404806.0) are proposed as solutions to ameliorate the issues raised above.
2.1 Consideration of type-one guards: a door frame with stone sill or low entrance threshold

Existing designs of frame mounted door aperture guards have a common weakness that the join between the base of the door aperture guard and the door sill (or step) can allow some seepage of floodwater to enter the property. This is because the base of the door aperture guard is subjected to the highest water pressure. Moreover, when fitting the door aperture guard to the doorframe it can be difficult to apply the correct downward force to the door aperture guard, whilst simultaneously trying to insert threaded bolts to fix it to the doorframe. The join between the bottom edge of the door aperture guard and the door sill must be properly compressed in order to form the necessary water resistant seal. Where the self-weight of the door aperture guard onto the bottom seal between the door sill and the guard is insufficient, it will fail to stop water seepage. Simply attempting to exert sufficient downwards force with one hand on the top edge of the door aperture guard. Also inserting threaded bolts and having to rotate the bolts at the same time, can be difficult even for a skilled operative. For a homeowner this is an even more challenging process; whereby, insufficient downwards force onto the door aperture guard and/or cross-threaded bolts and damage to threads, will lead to insufficient compression of seals and possible floodwater seepage into the property.

A new method is needed for doorframe mounted door aperture guards, in order to apply sufficient downwards force onto the door aperture guard bottom seal (~30% compression of seal thickness), as specified by the seal manufacturer, whilst also precisely aligning the bolt holes in the door aperture guard with threaded holes in the doorframe. Securing the door aperture guard in this position would then allow one unskilled person to have both hands free to insert the bolts and tighten them. This is extremely important for homeowners who may be unskilled with hand tools and, in the event of a flood, may find themselves needing to deploy door aperture guards in a hurry. Therefore, to overcome these problems, a new design of doorframe mounted aperture guard and fixings (Patent Pending GB1401368.4) pre-compresses the water seal against the sill and concomitantly hold the door aperture guard fixing holes in alignment so that both hands of the operative are free to insert necessary fixing bolts.

The door aperture guard can be precisely positioned on the doorframe so that fixing holes and doorframe threaded inserts are aligned for easy and rapid insertion of mounting bolts. Accurate lateral positioning of the door aperture guard automatically aligns the side fixing holes with doorframe threaded inserts. Once in position the seal on the bottom of the door aperture guard is pre-compressed to the correct amount in order to ensure a waterproof join at this most vulnerable point. The exact amount of downward force is automatically provided for the bottom seal so the waterproof seal is no longer dependent on operator skill and one person trying to exert downward pressure on the top of the door aperture guard, whilst also inserting and turning mounting bolts. With the bottom seal pre-compressed the guard will stay in place so that the homeowner has both hands free to insert the mounting bolts and, if necessary, use a spanner or driver.
Pre-compression of seal and automatic alignment of the door aperture guard allows it to be easily and quickly fitted by unskilled operatives even in difficult weather conditions. Mounting bolts into the doorframe may optionally be sited on the outside of the seals so floodwater cannot enter the property through fixing holes in the door aperture guard. An aesthetic appeal is the fixings are practically invisible, there being no permanent frames or channels fitted around the doorway to remind homeowners of their flood risk. Lack of external fixings offers a further advantage as the door aperture guard can be used on buildings in conservation areas. On listed buildings the door frames usually have a timber or stone sill and the feature of this door aperture guard assembly to pre-compress the bottom seal becomes of paramount importance in providing a waterproof seal against an often old, well worn, and uneven step.

2.2 Technical and diagrammatic descriptions of a type-one guard solution

Figure 1 is a line drawing to show the rear face of the aperture guard. The panel A with its integral perimeter frame B together form the basic door aperture guard. Seal D is fitted to the base of the door aperture guard in order to form a watertight join between the base of the door aperture guard and the door sill or step. Seal C is fitted on the rear face of the door aperture guard to provide a watertight seal against the outside face of a doorframe. Holes E, through the door aperture guard, are for threaded fixings or bolts to hold the sides of the door aperture guard to a doorframe, and tightening the fixing bolts will compress seal C. The ‘locating block’ F is temporarily attached to the doorframe by threaded fastener or bolt. The height of locating block F above the door step is set exactly so as to compress the door aperture guard bottom seal to the correct amount when the door aperture guard is pushed downwards on its top edge T and positioned under the two locating blocks F.

![Figure 1: Line drawing to show the rear face of the aperture guard (see main text for explanation of labels).](image-url)
These also serve to align the lateral position (side to side) of the door aperture guard in a doorframe. The outer edges of the locating blocks F are set so that when the outer edges of the door aperture guard are in alignment with them, the holes E in the door aperture guard will be exactly lined up with the threaded inserts in a doorframe to facilitate easy fitment of mounting bolts. When the door aperture guard bottom seal D is compressed against a door sill and the top of the door aperture guard T is pushed down and under the locating blocks L, the door aperture guard will be held in position so that both hands can be used to insert the mounting bolts through holes E. Thus, the aperture guard is accurately positioned and it is easy to insert the fixing bolts.

Figure 2 is a line drawing of the locating block F to show the relative positions of the top corner M of the door aperture guard and a doorframe G. The locating block F is fitted in a precise position by bolt L on the doorframe G in order to provide an answer to three problems with all existing door aperture guards: (i) The height of the locating block F on the doorframe G is set so that when the top edge T of the door aperture guard is pushed down and slid under the locating block F, the bottom seal M (as shown in Figure 1) is pre-compressed to exactly the correct amount to form a watertight joint between the bottom of the door aperture guard and the door sill or step, the guesswork associated with how much weight to exert onto the top of a door aperture guard whilst struggling to insert and turn threaded fasteners is removed by this feature; (ii) The outer edge and top corner M of the door aperture guard aligns exactly with the outer side J of the locating block F, so that the bolts inserted through holes E (as shown in Figure 1) will align exactly with the threaded inserts already set into the doorframe G which then by tightening the bolts fixes the door aperture guard sides to the doorframe G and compresses the seal C; and (iii) When the top edge T of the door aperture guard is pushed down and inserted under the locating block F it will remain in position due to the compression of the bottom seal D (as shown Figure 1) so the homeowner retains both hands free to insert mounting bolts and compress seal C. The locating block F can be fitted to the doorframe G using threaded fasteners into threaded inserts set into the doorframe so that it can be easily removed to leave no evidence of a flood door aperture guard installation at the property. The locating block F can be any shape provided that it has one face J suitable for the lateral alignment of the door aperture guard and also a lower face to allow the top edge T of the door aperture guard to slide under in order to pre-compress the door aperture guard bottom seal D (as shown Figure 1).

Figure 3 is a line drawing to show the door aperture guard fitted to the outside of a typical doorframe. The door aperture guard sits on the door sill K and the top edge of the door aperture guard T has been pushed downwards and slid under the locating block F which compresses the bottom seal D to form a watertight seal between bottom of door aperture guard and door sill K or step. The edges of the door aperture guard and the edge J of the locating block F are aligned so mounting bolts inserted through holes E will go straight into the threaded inserts installed in the doorframe G. After the flood event the locating blocks F can be unbolted from doorframe to remove all evidence of flood protection measures.
2.3 Consideration of type-two guards: UPVC door frame with UPVC sill

Any type of door aperture guard that fits directly onto the door frame relies on a watertight seal between the door frame and the external wall of the building to prevent floodwater ingress. It is often very difficult to ensure a completely watertight join between UPVC door frames and external walls due to differential rates of heat expansion. In particular, the join underneath the door sill is very prone to leakage and difficult to seal not only because of differing expansion but also continuous foot traffic tends to cause movement and damages to any applied sealants. The join below the door frame sill is also a tricky area to apply sealants as it is normally beneath a projecting sill and adjacent to external ground level
making the use of a conventional mastic sealant gun at best very awkward and often not practical.

Also, all UPVC door frames must have small diameter weep holes or vents in their lowest sill members to serve as an outlet for any water that may penetrate the glazing seals or condense on the inside of the frame members, otherwise the frames fill with water which then leaks into the building. These weep holes are usually shrouded by small plastic caps or hoods to let water out and prevent insect entry and can be found on the external face of the frame lower sill. Because of their location these weep holes are normally covered over by the deployment of the current range of conventional flood door aperture guards which rest on the door sill and are directly fixed to the door frame. However, many of the latest UPVC door frames now feature weep vents that are drilled vertically downwards in to the door frame sill itself with the water pathway passing down through the sill and exiting to atmosphere on the underside of the sill. Consequently these vent holes on the underside of the sill are not covered by any of the current range of aperture guards, which all rest on top of the sill. See websites [9] for details of latest UPVC door frame and sill drains. Therefore these hidden weep holes in the latest door set designs now serve as a direct pathway for flood water to enter through them, pass up through the lower frame members, into side frames and then via hinge and locking mechanism holes enter into and flood the building.

The issue of structural stability must also be considered when floodwater is resisted by the external walls of a building. There is an inherent weakness at any opening in a wall. To then attach a door aperture guard to a door frame, which must take the weight of flood water that comes to bear on the outside of the property is to apply even further loading to a structural weakness, may result in expensive damage. Research by USAC in America showed that walls loaded with increasing floodwater depths always failed first at the sides of openings [10].

A new design is needed for a flood water aperture guard that does not rely on a watertight seal between the sides of a door frame and the external walls and also the underside of the sill and external walls. The new aperture guard must also provide a waterproof seal around the sill itself because of the frame profile manufacturers’ new practise of locating weep holes on the underside of the sills. Also, fixing across an opening from brickwork to brickwork will reduce the intrinsic weakness that results from forming openings in external walls and allow the building to resist a greater depth of floodwater. Therefore, a new design (Patent Pending GB1404806.0) features an aperture guard that uses structural fixings onto the external wall face at the sides of the opening and below the UPVC door frame sill.

The aperture guard is composed of two separate parts that are adjusted to the particular location and then fixed together as part of the installation process. The external faces of a door frame are smooth, true and planar for the quick and easy attachment of the current range of aperture guards but the brickwork surrounding an aperture is uneven and very often the vertical reveals at the sides of the opening have misaligned brickwork which makes it impossible to achieve a waterproof join between the brickwork faces around the sides of the aperture and a conventional
planar aperture guard. The two part construction of the aperture guard allows an adjustment during installation to combat misalignments in brickwork and so achieve a waterproof seal between the completed aperture guard and brickwork surrounding the opening.

The latest designs of UPVC door frames that feature hidden weep holes on the underside of sills and/or via sill end caps can now be protected from floodwater ingress. It is no longer necessary to have a watertight join between the door frame sides and the surrounding external wall. Similarly, it is no longer necessary to have watertight join between the underside of the door frame sill and the external wall below it. This is because the aperture guard spans across the opening to securely fix (chemical anchor bolts) on brickwork at the sides and bottom of the aperture its deployment strengthens the area of structural weakness that is a direct result of forming openings in walls. The external wall fixings are all but indiscernible, there being no permanent frames or channels built-in around the doorway aperture that serve to remind homeowners of their flood threat. The lack of external fixings means that the door aperture guard can be used in conservation areas.

This type of aperture guard can be fitted across door sets that have both inward and outward opening doors which is a major feature as most patio type door sets open outwards which preclude the use of the current range of frame fixed aperture guards. As the aperture guard spans across the opening to fix and strengthen brickwork at the sides and bottom of the aperture it can be used to protect increased width ‘French’ or double door sets.

The use of ‘chemical anchors’ (e.g. resin bedded bolts) into external walls allows a watertight fixing to be made as opposed to open ended door frame fixings which may leak floodwater into the building. Similarly, chemical anchors into external walls at the centre of brick units in order to support a frame, which actually bridges the opening, increases the structural strength of the opening and allow the building to resist an increased depth of floodwater.

2.4 Technical and diagrammatic descriptions of a type-two guard solution

Figure 4 is a line drawing to show the rear elevation of the first component which is the outer frame of the aperture guard. The angle profile A has a rear face D onto which is attached a waterproof seal B. The seal B provides a waterproof seal between the rear face D and the external wall around the aperture or opening. The outer frame can be fixed to any type of aperture in an external wall. The outer frame is attached to the external wall using chemical anchor bolts which pass through holes C in the rear face D. The fixing holes C are drilled through D on site so that they are positioned in the centre of any brick units and not into weaker mortar joints. In many cases the external walls on the sides of an aperture will be uneven and will not be planar and so the resin anchors inserted through holes C will be tightened progressively in order to distort the outer frame so that the seal B is held in continuous and equidistant contact with the external wall face to produce a watertight seal between outer frame rear face D and wall. The continuous equidistant contact between external wall and outer frame serves to strengthen the structure across the opening in the wall as the outer frame is securely fixed along three sides of the opening.
Figure 4: Line drawing to show the rear elevation of the first component which is the outer frame of the aperture guard (see main text for explanation of labels).

Figure 5 is a line drawing to illustrate the initial installation. The outer frame A is attached with resin anchors F to the external wall at the side sections and also along the bottom section of the outer frame A. Typical brickwork shown as H and G on opposing sides of the aperture are not exactly in line and so as the resin anchors F are tightened the outer frame A twists so that the seal B remains sandwiched equidistantly between rear face D and the external wall so as to ensure a watertight seal between them.

Figure 5: Line drawing to illustrate the initial installation (see main text for explanation of labels).

Figure 6 is a line drawing to show the second component of the adjustable aperture guard – a barrier board. The barrier board is a planar rectangular waterproof board typically made from a waterproof board J surrounded by a stiffening channel frame L.
Figure 6: Line drawing to show the second component of the adjustable aperture guard – a barrier board (see main text for explanation of labels).

Figure 7 is a line drawing to show the fully assembled and installed adjustable aperture guard. The stiff barrier board is permanently fixed into the outer frame using fixings K around its perimeter. The brickwork at the sides of the aperture shown as G and H are not planar and are not aligned. Therefore, the outer frame A twists when its rear face D is tightened down onto the brickwork, to enable a uniform watertight seal by sealing strip B. The planar barrier board is then permanently fixed into the twisted outer frame with fixings K. The sides of the barrier board will not align exactly with the edges of the outer frame A because the outer frame A has been twisted by the misaligned brickwork as shown at M. Mastic sealant and fixings K provide a permanent secure and waterproof join between outer frame A and the barrier board channel member L. The adjusted and completed aperture guard is then removed from the external wall by removal of nuts from the resin anchors F and retained as one complete unit ready to be deployed in the event of a flood. The fitted twisted shape of the outer frame will

Figure 7: Line drawing to show the fully assembled and installed adjustable aperture guard, with the barrier board fixed into the outer frame (see main text for explanation of labels).
be retained so that a watertight seal between rear face D and brickwork is achieved when the aperture guard is refitted. Once fitted to a particular aperture the outer frame A and barrier board remain assembled and when fitted to the wall serve to strengthen the intrinsic structural weakness across the wall opening.

The strength of the barrier board with its channel frame L, the permanent fixings K and the resin anchors used for fixings F all around the ‘U’ shaped perimeter of the outer frame result in increased structural strength by bridging across and below the aperture to allow the building to safely resist a much greater depth of floodwater without causing structural damage. The height of the outer frame allows its base section to be fixed with chemical anchors to the brickwork below the aperture, thereby not only preventing floodwater from entering via vent holes that maybe in the underside of a door frame sill but also greatly increasing the structural strength across the lower area of the aperture. The size of the outer frame angle provides sufficient stand-off from the external wall to enclose and protect a door frame sill that protrudes out from the external wall face. The width of the outer frame is sufficient to span across onto the brickwork at the sides of the aperture, and enclose and protect the ends of a door frame sill that may be fitted into the aperture.

5 Conclusions

Door aperture guards remain the only affordable flood resistance solution for many homeowners. Yet the products themselves can be problematic to install and the fittings serve as an everyday reminder of living in a flood risk home. This study has provided solutions to the issues surrounding both of the existing types of commercially available products by demonstrating the practical advantages of Patent Pending GB1401368.4 and GB1404806.0 door aperture guards over those of existing designs and systems. The first type of barrier (GB1401368.4), which is for a step or low profile sill, is easy to deploy and is the first barrier to compress the vulnerable barrier bottom seal to ensure a watertight fit. The second type of barrier (GB1404806.0), which is for the latest UPVC door sets, uses resin anchors to hold a rigid frame that spans the brickwork below damp proof course and brick reveals; thereby, strengthening the at risk aperture reveals, whilst also protecting any weep holes that are located beneath the sill. These barriers have fixings that are hardly visible and they offer the added advantage for being suitable for use in conservation areas. Furthermore, as there appears to be no current flood door with a low profile threshold, they remain the sole answer for door sets used to provide the necessary accessibility for disabled persons.

These practical designs offer an easy to deploy barrier that can span very wide apertures, whilst also offering structural support to the brickwork reveals, which are the areas most susceptible to damage by pressure exerted by the floodwater. However, in order to make these products available to flood victims it would be necessary to secure sufficient funding so they can be tested to BSI Kitemark Accreditation to pass the testing criteria of PAS 1188-1: 2009.
References


[9] www grpdesigns.co.uk