Flood Risk Assessment

Works	Proposed Residential Development
Site Address	at 1-9 Eastoft Road Crowle North Lincolnshire DN17 4LP
Client	Mr P. Nicholson
Reference	839CROW
Date	June 2019

keystone**architecture** Limited
Britannia House, High Street
Scunthorpe, North Lincolnshire, DN15 6EA

Tel: 01724 230 122
E-mail: info@keystonetechnical.co.uk
Website: www.keystonetechnical.co.uk

Registered office at above address. Registered in England No. 10401018

<u>Flood Risk Assessment</u>

-	14th June 2019	Planning Issue
A	*18th March 2024*	*Site and FFL's Amended*

839CROW – Residential Development at 1-9 Eastoft Road, Crowle, North Lincolnshire, DN17 4LP

Assessment

Assessment

1.0 Preamble

1.1 The Flood Risk Assessment will accompany a Planning Application for 14no. New Dwellings on land to the West off The Link, Ashby, North Lincolnshire.

1.2 The proposed site, known presently as R. Nicholson Motors, at 1-9 Eastoft Road, Crowle, North Lincolnshire, DN17 4LP, is located immediately North of the junction of Eastoft Road, Mill Road, Woodland Avenue and Fieldside, to the North East of the centre of Crowle. The Market Town of Crowle is in a rural location, but well served with its own services and town centre.

1.3 The level of the site is circa 7.600m AOD. The River Trent is approximately 4.2 miles to the East, and is considered the primary (tidal) flood risk to the site. Crowle is slightly elevated from the surrounding land, which is only a few meters above the marsh level. The local drains around Crowle are pumped to maintain water levels, and as such carry a flood risk associated with the loss of the pumps.

1.4 The purpose of this assessment is to comply with National Planning Policy Framework (NPPF); to enable an investigation into the potential flood associated risks relating to the development. The purpose of the Flood Risk Assessment is therefore to: -

- Demonstrate whether a particular project is likely to be affected by flooding from any source, both now and in the future;
- Satisfy the Local Planning Authority that the development is safe and, where possible, reduces the flood risk overall.
- Demonstrate whether it will increase the flood risk elsewhere.
- Demonstrate the measures proposed to deal with the identified risks.

2.0 Sequential Test

2.1 Below is an extract of the Environment Agency Flood Zone Map, showing the proposed site location.

2.2 The proposed site is in an area which falls outside the extent of a flood from a river or the sea, at the time of assessment of the likelihood of flooding. This is known as a Flood Zone 1.

Generally this means that the chance of flooring each year from rivers or the sea, is 0.1% (1 in 1000) or less.

It is important to note however, that these flood zones refer to the probability of river and sea flooding, ignoring the presence of defences.

2.3 Taking the Environment Agency Flood Zone Map, it would be considered that the proposal for the new houses, deemed 'more vulnerable', would be acceptable in this area.

2.4 The North Lincolnshire Council Strategic Flood Risk Assessment (SFRA) identifies the site as inside a Flood Zone 1 Low Probability, as shown SFRA extract below:

Generally this means a site that has land assessed as having less than a (<0.1%) 1 in 1000 annual probability of river or sea flooding in any year.

keystone**architecture** Limited
Britannia House, High Street
Scunthorpe, North Lincolnshire, DN15 6EA

Tel: 01724 230 122
E-mail: info@keystonetechnical.co.uk
Website: www.keystonetechnical.co.uk

2.5 This Zone 1 under the National Planning Policy Framework Technical Guidance (below), equates to a Low Probability.

Zone 1 - low probability

Definition
This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%).

Appropriate uses
All uses of land are appropriate in this zone.

Flood risk assessment requirements
For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment. This need only be brief unless the factors above or other local considerations require particular attention.

Policy aims
In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems[2].

2.6 Taking NPPF Table 2 (below), dwelling houses are defined as 'more vulnerable' classification.

More vulnerable

- Hospitals.
- Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels.
- Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels.
- Non–residential uses for health services, nurseries and educational establishments.
- Landfill and sites used for waste management facilities for hazardous waste[6].
- Sites used for holiday or short-let caravans and camping, *subject to a specific warning and evacuation plan*.[7]

2.7 NPPF Table 3 (below) confirms a More Vulnerable use on the site within a Zone 1 is considered appropriate.

Flood Risk Vulnerability		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test Required	✓	✓
	Zone 3a	Exception Test Required	✓	✗	Exception Test Required	✓
	Zone 3b (Functional Floodplain)	Exception Test Required	✓	✗	✗	✗

Key:

✓ Development is appropriate

✗ Development should not be permitted

3.0 Exceptions Test

3.1 Paragraph 102 of the NPPF allows the application of the Exception Test by the LPA. The Exception Test provides a method of managing flood risk while still allowing development to occur.

There are two elements to the Exception Test as set out below. Both elements need to be passed.

a) It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and

b) A site-specific flood risk assessment (FRA) must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible will reduce flood risk overall.

3.2 The NLC SFRA contains critical flood levels for this area, which are set at 4.100m AOD. This is a level set taking into account a fluvial 1 in 100 return period, and a tidal 1 in 200 return period, allowing for climate change.

The site level is approximately 7.600m AOD, which means the site is not at risk from a 1 in 100 year fluvial event or 1:200 year tidal event.

Appendix F of the SFRA recommends a mitigation measure to raise floor levels at least 300mm above the Critical Floor Level, as above.

The proposed dwellings will have a ground floor level around **8.100m** AOD, significantly above the safe 300mm above the CFL level.

3.3 The new properties shall be constructed within the development boundary of Crowle, amongst existing dwellings, within the centre of the town, which is considered highly sustainable.

3.4 There is a continued shortage of high quality, market affordable housing in rural locations, and the creation of the proposed new dwellings will enhance the local area, providing suitable market affordable housing and additional support to the local amenities.

3.5 The construction of the properties will also provide employment for local tradesmen, including local builders and sub-contractors, offering wider sustainable benefits to the community.

3.6 Crowle is one of 5 Market Towns within the North Lincolnshire Core Strategy earmarked for development and expansion, including provisions for additional housing.

3.7 It is confirmed that there are no other available sites within the immediate location which meet all of the requirements of the proposal, especially in lower flood zones. The town has limited development opportunities as it is surrounded by open countryside, most of which is in a higher category Flood Zone. There are no available sites in lower flood zones, as the application site is in the lowest flood zone Flood Zone 1).

3.8 The site is currently considered as 100% impermeable, as the current site is entirely concrete / tarmac hardstanding, which is drained into the sewer system.

The area is not known to suffer from any groundwater problems and therefore is taken as having no strategic significance as regards to flood risk.

The existing drained area from the site totals 2,650m². The combined adoptable road and roof drained area totals 1,388m². The soft-landscaped and garden areas, coupled with the permeable parking bays, reduces the surface water run-off from the site by 1,262m², or nearly 50%. This reduction in drained area reduces the impact on the sewer system as a result of the development.

Soakaways are not considered as the site is not large enough to accommodate them.

4.0 Conclusion

4.1 As the site is in a ‘Zone 1, Low Probability’, and the proposed vulnerability is classed as ‘More Vulnerable’, it is noted that an Exception Test is NOT required.

4.2 The proposed ground floor level of the dwellings shall be set at 8.100m AOD, significantly higher than the 300mm above the CFL of 4.100m as noted in NLC SFRA.

4.3 The construction will be based on flood resistant construction elements, with regard to the use of concrete, plaster etc. and services will be served from above. All new walls at low level, are to be masonry construction, with hard plaster finish internally, to provide low permeable construction.

More information can be found on flood resilient construction methods in Appendix A, which includes an extract of the Communities and Local Government document ‘Improving the Flood Performance of New Buildings’,

4.4 Electrical fittings shall be located as high as possible within the current standards, and ring mains and services shall be located at ceiling level and dropped down to the outlet.

4.5 The development of the site will see a reduction of around 50% in off site run off, reducing the impact on the mains sewers.

4.6 It shall be recommended that the new home owners sign up to the 'Floodline Warnings Direct' courtesy of the Environment Agency, which will alert them in the event of a potential risk of flooding to the site, allowing them to take the most appropriate action.

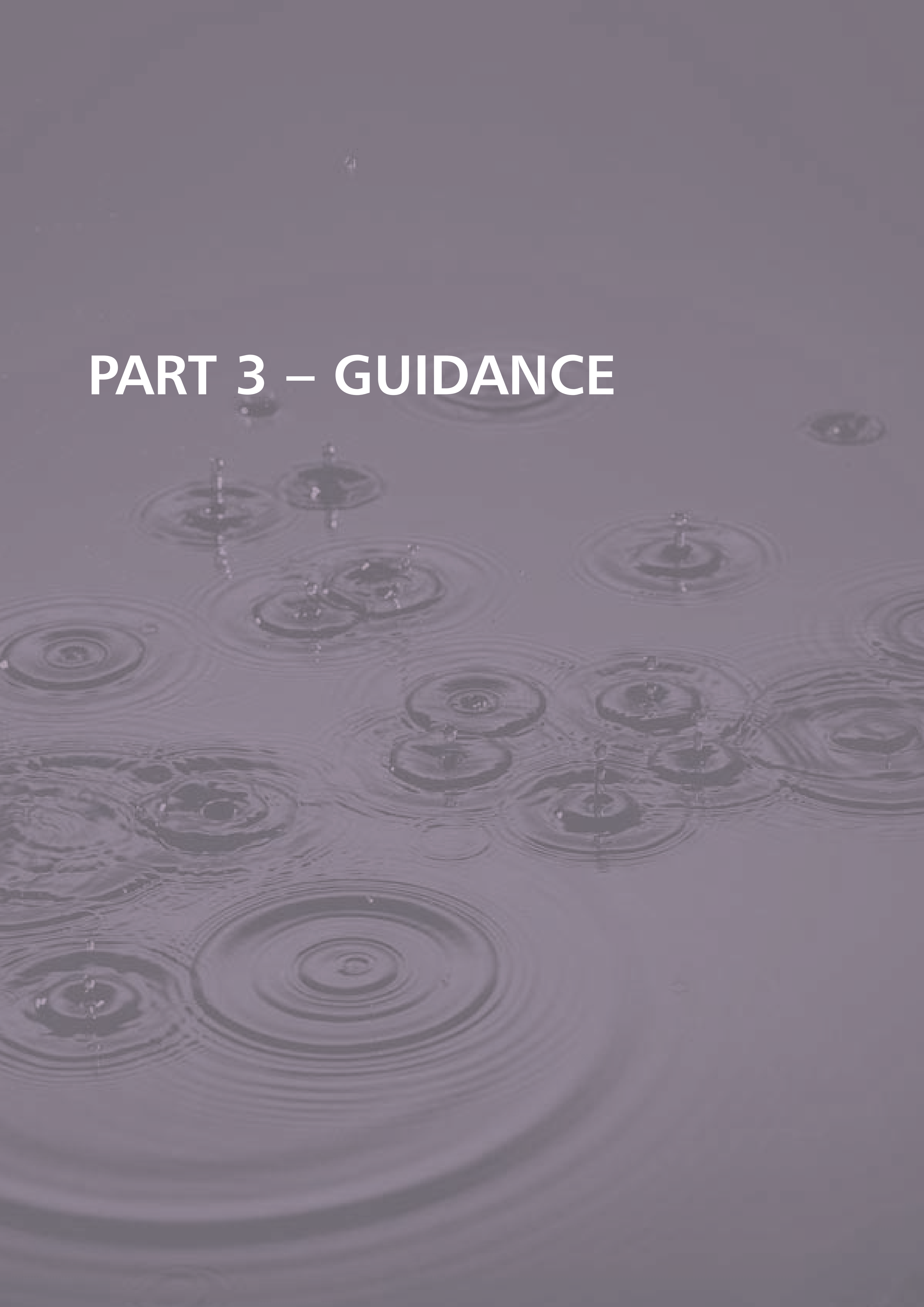
4.7 The dwellings fall outside of an area liable to flooding under the Environment Agency Flood and NLC SFRA maps, and are therefore deemed appropriate.

4.8 As a result of the above and the previous, it is considered that the development is acceptable with regards to flood risk.

APPENDIX A

COMMUNITIES AND LOCAL GOVERNEMNT – IMPROVING THE FLOOD PERFORMANCE OF NEW BUILDINGS – FLOOD RESILIENT DESIGN AND CONSTRUCTION

PART 3 – GUIDANCE



6 Guidance on flood resilient design and construction

6.1 General principles

Management of flood risk can be achieved during the planning and outline design stages for any new development as discussed in Chapters 3 (Planning Policy and Building Standards) and Chapter 4 (Design Strategies). This chapter is concerned with measures aimed at achieving flood resilience that can be applied at the building design level. This chapter provides technical guidance on building materials and forms of construction (and to a lesser extent, on fittings) that are appropriate for improving the flood resilience of buildings. It is the result of a synthesis of information from a number of different sources: published literature, review of existing practice, experiential information, and laboratory testing. Some recommendations in this Guidance naturally differ from current standards, such as those contained in the NHBC, in order to address the severity of exposure to flood water which hitherto has not been considered.

Any resilience measures should be designed so that the building can be occupied safely over its proposed lifetime taking climate change into account.

It is generally accepted that total prevention of water ingress or 'dry proofing' to a building is very difficult to achieve. The strategies that are recommended to minimise flood impact to buildings and their occupants are described in Figures 4.2 to 4.4 of Chapter 4. In terms of achieving resilience, there are two main strategies, whose applicability is dependent on the water depth the property is subjected to (see Chapter 4).

- **Water exclusion strategy** – where emphasis is placed on ***minimising*** water entry whilst maintaining structural integrity, and on using materials and construction techniques to facilitate drying and cleaning. This strategy is favoured when low flood water depths are involved (not more than 0.3m). According to the definitions adopted in this Guidance, this strategy can be considered as a resistance measure but it is part of the aim to achieve overall building resilience

- **Water entry strategy** – where emphasis is placed on allowing water into the building, facilitating draining and consequent drying. Standard masonry buildings are at significant risk of structural damage if there is a water level difference between outside and inside of about 0.6m or more. This strategy is therefore favoured when high flood water depths are involved (greater than 0.6m).

Other important factors that should be considered for resilient design and construction, but not addressed in this guidance, are:

- cost

- durability

- ease and practicability of construction
- environmental, social and aesthetic acceptability.

Guidance is provided in the following sections:

Section 6.2 – building materials

Section 6.3 – foundations

Section 6.4 – floors

Section 6.5 – walls

Section 6.6 – doors and windows

Section 6.7 – fittings

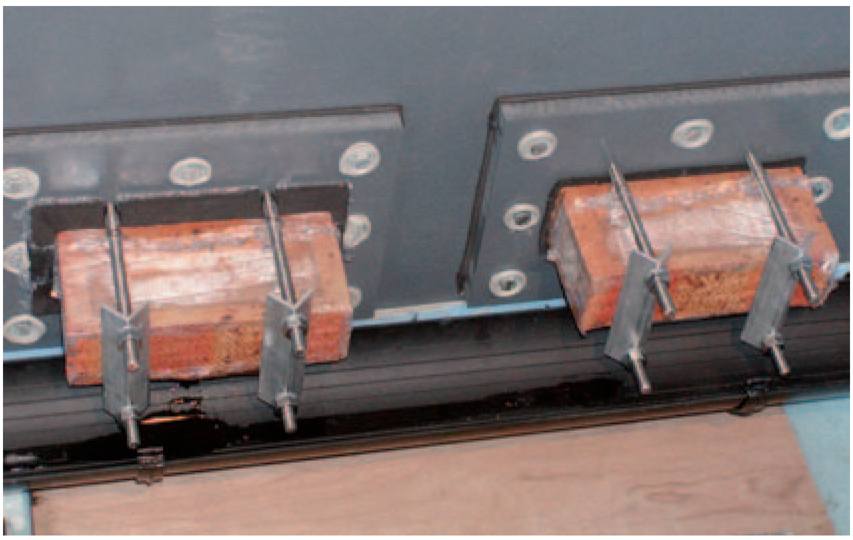
Section 6.8 – services.

In each section dealing with construction elements (e.g. materials, foundations, floors, and walls) there is a brief discussion of the design issues, followed by general advice on resilience. Some illustrative sketches are also included which provide information on general arrangements but do not cover construction details.

6.2 Building materials

The recommendations given in this section on building materials are based primarily, but not exclusively, on recent laboratory investigations (permeability and drying tests on 13 typical building materials subjected to 1m head of flood water). An illustrative example of testing is given in Figure 6.1.

Figure 6.1 **Pressed facing bricks being tested**



Although this guidance covers the main types of building material commonly in use in the UK for typical domestic construction, it should be borne in mind that other materials also may prove to be suitable for resilient constructions. It should also be noted that there is variability within materials that may affect their resilience performance. As expected, the denser materials such as concrete and engineering bricks were found to have good resilience characteristics. In general, the findings of the materials testing confirmed existing knowledge and experience but provided new quantitative data on construction material behaviour.

Table 6.1 presents the characteristics of common building materials, tested in the laboratory, classified as having good, medium or poor performance with regard to water penetration, drying ability and integrity.

Definitions of the characteristics used in Table 6.1 are:

- water penetration – the seepage (rate and volume) through the material (note that this is different from "water absorption")
- drying ability – the capability to regain its original moisture condition (assessed by the average drying rate and the time taken to reach the original value)
- retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the material

Table 6.1 **Flood resilience characteristics of building materials (based on laboratory testing)**

Material	Resilience characteristics*		
	Water penetration	Drying ability	Retention of pre-flood dimensions, integrity
Bricks			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Facing bricks (handmade)	Poor	Poor	Poor
Blocks			
Concrete (3.5N, 7N)	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Timber board			
OSB2, 11mm thick	Medium	Poor	Poor
OSB3, 18mm thick	Medium	Poor	Poor
Gypsum plasterboard			
Gypsum Plasterboard, 9mm thick	Poor	Not assessed	Poor
Mortars			
Below d.p.c. 1:3(cement:sand)	Good	Good	Good
Above d.p.c. 1:6(cement:sand)	Good	Good	Good

* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth

Chapter 6

Clearly other factors affect the choice of resilient building materials, namely their insulating properties, ease of handling, availability, aesthetics, cost, etc. and these should also be considered when specifying materials for construction in flood-prone areas.

Building materials that are effective for a 'water exclusion strategy' include: engineering bricks, cement-based materials including water retaining concrete and dense stone.

Building materials that are suitable for a 'water entry strategy' include: facing bricks, concrete blocks, sacrificial or easily removable external finishes or internal linings.

6.3 Foundations

Foundations are designed to suit site conditions, namely the local geotechnical characteristics and the building design. Strip and trench-fill foundations are generally used where no special problems are identified, whereas raft, pile, pier and beam foundations may be necessary in other cases. In general, the choice of foundation type will be dictated by ground conditions, rather than resilience considerations. However, improvements can be made to increase the resilience.

For typical two-storey dwellings shallow footings are likely to be appropriate in most cases. It is common practice to use concrete blocks as substructure elements in typical cavity wall buildings but laboratory work has shown that groundwater can penetrate through the blocks into the wall cavity (and from there into the building) if care is not taken to minimise the passage of water. There is a general recommendation in the NHBC Standards, 2006) to allow a clear cavity of at least 225mm below damp proof course (d.p.c.) to prevent the build up of any mortar dropped during construction from having a detrimental effect on the performance of the wall. However, this unsealed void may be an entry point for rising ground water into the property via the blockwork.

Basements are a separate category of construction which can benefit from various types of tanking methods to provide an effective barrier to flood water. Guidance on tanking can be found, for example, in publications such as CIRIA Report 139 'Water-Resisting Basement Construction – A Guide' (CIRIA, 1995), NHBC Standards (2006). It is not advisable to design for living accommodation in basements, where there is a risk of flooding.

6.3.1 Water exclusion strategy

A general principle for flood resilient design where predicted flood water depths are relatively small (no greater than 0.3m above floor level) is to minimise the entry of water through permeable elements of the foundation. Any concrete blocks placed below ground-bearing concrete floor slabs provide a potential path for water to ingress into wall cavities, as these blocks are considerably more permeable than concrete slabs. Figures 6.2 and 6.3, illustrating a ground bearing slab and a concrete suspended floor slab, show a potential flow path from the ground adjacent and under a dwelling, through porous substructure and into the wall cavity. The use of concrete or another impermeable material to seal the blocks may resolve this problem. The figures highlight the fact that measures taken above ground level may not fully prevent the ingress of water.

Figure 6.2 **Water ingress into properties through the ground – ground bearing floor**

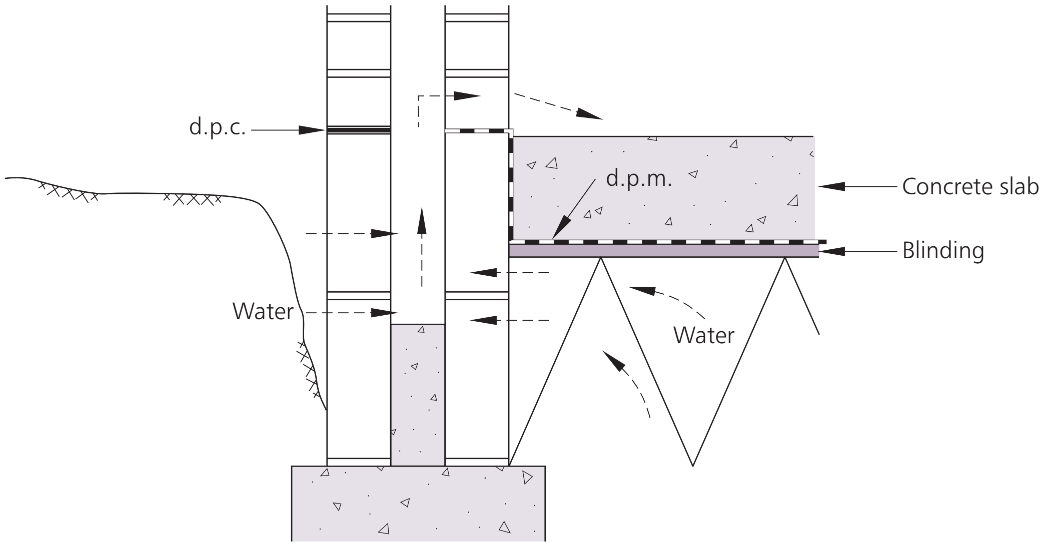
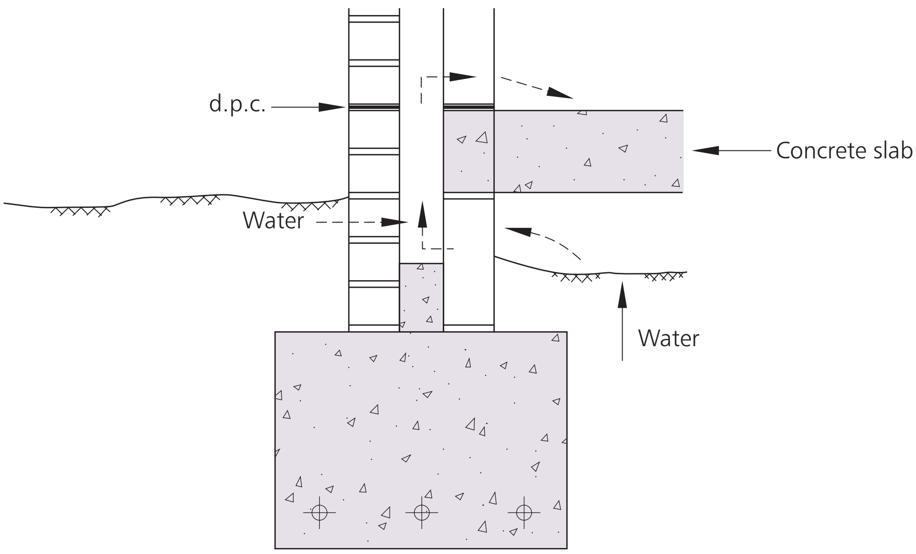


Figure 6.3 **Water ingress into properties through the ground – suspended floor**



> **General advice for resilient design**
>
> Where concrete ground floor slabs are used, the blockwork substructure is often the weakest point in terms of water penetration from the ground into a dwelling. Whereas there is a general perception that water can ingress through the blockwork structure of the external face of a wall into the property, it is less apparent, but equally possible, that water will penetrate from the ground on the inside of the property. Figures 6.2 and 6.3 illustrate these flow paths for two types of ground floor (ground bearing floor and suspended concrete floor), and different types of foundation (typical for construction in England).
>
> Concrete blocks used in foundations should be sealed with an impermeable material or encased in concrete to prevent water movement from the ground to the wall construction.

6.3.2 *Water entry strategy*

> **General advice for resilient design**
>
> A general principle for flood resilient design where predicted flood water depths are high is to provide durable materials that will not be affected by water and use construction methods and materials that promote easy draining and drying.
>
> Standard methods and good quality building materials will generally comply with these requirements but good workmanship is essential.

6.4 Floors

The behaviour of ground floors in floods can be influenced by two different conditions:

- water ingress from the ground (potentially resulting in uplift pressures), and
- exposure to standing water.

Of the above two situations (which can occur simultaneously), water ingress from the ground is potentially more severe as it is more likely to affect the structural integrity of the floor. Structural calculations may need to be carried out to ensure that the floor (including any lateral support provided at the perimeter) has the necessary strength to resist uplift forces without excessive deformation or cracking.

6.4.1 *Water exclusion strategy*

When applying a "water exclusion strategy" (i.e. minimising water ingress through ground floor slabs), for predicted water depths above the floor of greater than 0.3m, it is important to carry out structural checks assuming a flood depth of 1m minimum above the slab, even in areas where the design flood water depth is lower. Usual safety factors must be applied in all such calculations (floors and walls). Laboratory evidence on small slabs (0.5m by 0.5m) indicated that 150mm thick concrete slabs on supporting soil can withstand such forces without allowing water ingress. However, for larger slabs, uplift forces may cause deformation and induce cracking and lead to preferential paths for water ingress.

General advice for resilient design

Ground supported floors are the preferred option and concrete slabs of at least 150mm thickness should be specified for non-reinforced construction. Hollow slabs are not suitable if the elements are not effectively sealed.

Suspended floors may be necessary where ground supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay) or where the depth of fill is greater than 600mm. Uplift forces caused by flood water may affect the structural performance of a floor. Suspended floors are generally not recommended in flood-prone areas, for the following reasons:

– the sub-floor space may require cleaning out following a flood, particularly a sewer flood. In order to aid this process and where accumulation of polluted sediment is expected, the sub-floor space should slope to an identified area and be provided with suitable access

– if cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space. Cheaper, sacrificial, finishes would be the best option.

– the steel reinforcement in the concrete beams of 'beam and block' floors may be affected by corrosion and its condition may need to be assessed following repeated or prolonged floods.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Reinforced concrete floors are acceptable but may be prone to corrosion of any exposed steel in areas of prolonged flooding.

Hardcore and blinding: good compaction is necessary to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are overlaps of 300mm, and also taping (mastic tape with an overlap of 50mm minimum). Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution.

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. Insulation placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed. However, water entry may cause insulation to float (if associated with low mass cover) and lead to debonding of screeds.

No firm guidance can be provided on best location for insulation where the primary source of flooding is from groundwater. For other types of flooding, placing insulation below the floor slab may be adequate but it is important to recognise that the characteristics of the insulation may be affected by the uplift forces generated by the flood water.

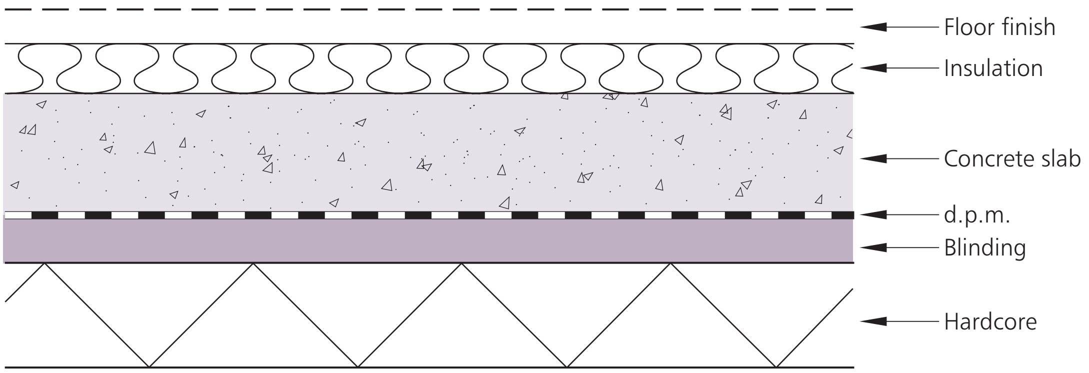
Floor finishes: suitable floor finishes include ceramic or concrete-based floor tiles, stone, and sand/cement screeds. All tiles should be bedded on a cement-based adhesive/bedding compound and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material. Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable.

Floor sump: provision of a sump and small capacity automatic pump at a low point of the ground floor is recommended in cases where the expected probability of flooding in any one year is 20% or a frequency of flooding of more than once in five years (see Section 4). This system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the planning authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Recommended ground-supported and acceptable suspended floor arrangements are presented in Figures 6.4 to 6.6. If suspended timber flooring is a favoured option, then a combination of construction elements that is likely to minimise problems associated with flooding is shown in Figure 6.6. This is referred to as a "Restricted option"

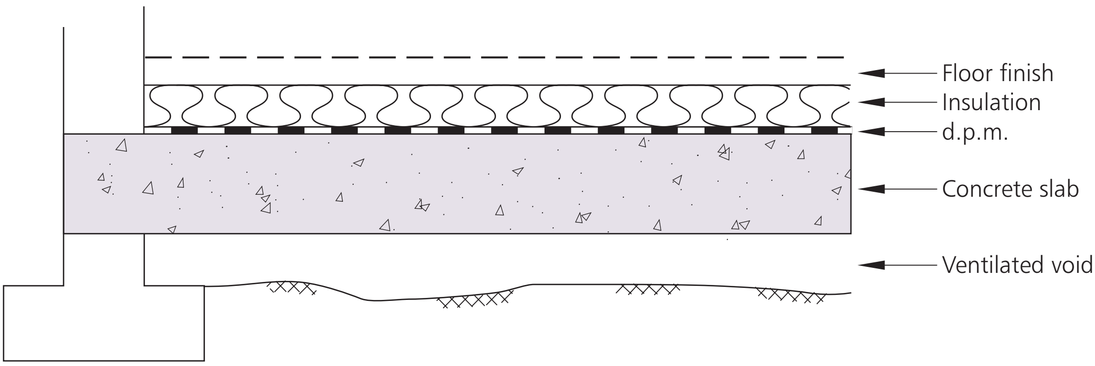
Figure 6.4 **Ground-supported floor – Preferred option**



- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Damp proof membrane of polythene at least 1200 gauge
- Concrete slab at least 150mm thick
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and skirting boards.

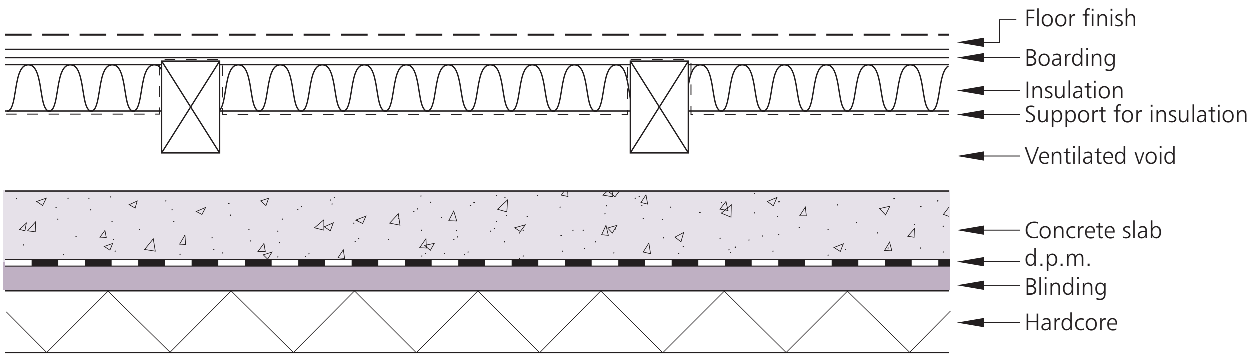
Figure 6.4 shows floor insulation above slab and there is laboratory evidence to support this location but there is currently no sound evidence to prevent the use of below slab insulation.

Figure 6.5 **Suspended Concrete Floor – Acceptable option**



- Reinforced concrete slab at least 150mm thick and complying with structural requirements for uplift forces
- Damp proof membrane of polythene at least 1200 gauge
- Insulation as rigid closed-cell material
- Ceramic tiles or stone floor finishes and including skirting boards.

Figure 6.6 **Suspended Timber Floor – Restricted option**



- Hardcore bed at least 100mm thick of well compacted inert material, blinded with fine inert material to provide a smooth base
- Concrete slab at least 150mm thick
- Insulation as rigid, closed cell material and supported with battens, plastic mesh or corrosion-resistant fixings
- Boarding consisting of WBP Plywood and preservative treated timber
- Stainless steel hangers

6.4.2 *Water entry strategy*

General advice for resilient design

Materials that retain their integrity and properties when subjected to flood water (such as concrete) or those that can be easily replaced (sacrificial materials), should be specified. Construction should allow easy access for cleaning, (e.g. below suspended floors), and drainage.

Concrete ground-supported floors are the preferred option and concrete slabs of at least 100mm thickness should be specified.

Suspended floors may be necessary where ground-supported floors are not suitable, namely in shrinkable/expanding soils (e.g. clay soils) or where the depth of fill is greater than 600mm. In cases of prolonged floods, where flood water is heavily silted, or from sewer flooding, the sub-floor space may require cleaning out following a flood; to aid this process, it should slope to an identified low point and be provided with suitable access. If cleaning is required, floor finishes may need to be removed to provide access to the sub-floor space and therefore cheaper, sacrificial, finishes would be the best option. Alternatively, external access to the sub-floor space can be considered as a design option.

Suspended steel floors may be adequate provided they incorporate resilient features such as anti-corrosion properties and comply with required structural capability.

Suspended timber floors, particularly when including timber engineered joists, are not generally recommended in flood prone areas because most wooden materials tend to deform significantly when in contact with water and therefore may require replacement. Rapid drying can also cause deformation and cracking.

Hardcore and blinding: good compaction should be achieved to reduce the risk of settlement and consequential cracking.

Damp Proof Membranes (d.p.m.) should be included in any design to minimise the passage of water through ground floors. Impermeable polythene membranes should be at least 1200 gauge to minimise ripping. Effective methods of joining membrane sections are: overlaps of 300mm or taping with mastic tape with an overlap of 50mm minimum. Care should be taken not to stretch the membrane in order to retain a waterproof layer. Experience in Scotland has indicated that welted joints in the d.p.m. are an effective jointing solution but the quality of the welts is very dependent on workmanship.

Chapter 6

Insulation materials: Water will lower the insulation properties of some insulation materials. Floor insulation should be of the closed-cell type to minimise the impact of flood water. The location of insulation materials, whether above or below the floor slab, is usually based on either achieving rapid heating of the building or aiming for more even temperature distribution with reduced risk of condensation. It is recommended that insulation be placed above the floor slab (and underneath the floor finish) rather than below would minimise the effect of flood water on the insulation properties and be more easily replaced, if needed.

Floor finishes: there are two possible approaches that depend on an assessment of the likely frequency of flooding and cost of material and installation: use of sacrificial materials or reliance on high quality durable materials – see Section 4. Sacrificial floor finishes can include timber flooring and soft furnishings such as carpets. Materials that are likely to withstand exposure to floodwater without significant deterioration are ceramic or concrete-based floor tiles, marble or stone. All tiles should be set on a bed of sand and cement render and water resistant grout should be used. Concrete screeds above polystyrene or polyurethane insulation should be avoided as they hinder drying of the insulation material due to the relative impermeability.

Suitable materials for skirting boards include ceramic tiles and PVC. Ceramic tiles are likely to be more economically viable and environmentally acceptable. Replacement timber may be a suitable option, for cases where a strategy to use of sacrificial materials is adopted.

Floor sump: provision of a sump and small capacity pump in the floor at a low point of the ground floor is recommended in cases where the expected frequency of flooding is high; this system will help the draining process and speed up drying but it may only be effective for shallow depth flooding. The dimensions of the sump and its operational procedure would be calculated and agreed with the Planning Authority based on the predicted volumes of water to be drained.

Services: under floor services using ferrous materials should be avoided.

Figures 6.4 and 6.5 illustrate recommended floor designs for the water-entry strategy.

6.5 Walls

The recommendations given in this section on wall construction are based primarily on recent laboratory investigations, but are supported by expert opinion and experience from the building industry – see Chapter 7. The laboratory tests covered 16 wall panels (approximately 1.1m high by 1m wide) of composite construction subjected to 1m head of water and then allowed to dry naturally. This is not an exhaustive list of constructions and other wall designs may also have adequate resilience characteristics.

Table 6.2, based on the laboratory evidence, classifies wall components as good, medium or poor with regard to water penetration, surface drying and structural integrity.

Definitions of the characteristics used in Table 6.2 are:

- water penetration – the leakage (rate and volume) through the entire wall thickness (note that this is different from “water absorption”)
- drying ability – the capability to regain its original surface moisture condition (assessed by the average drying rate and the time taken to reach the original value)
- retention of pre-flood dimensions, integrity – the lack of deformation or change in form or appearance of the wall panel.

Table 6.2 **Flood resilience characteristics of walls (based on laboratory testing)**			
Material	Resilience characteristics*		
	Water penetration	Drying Ability	Retention of pre-flood dimensions, integrity
External face			
Engineering bricks (Classes A and B)	Good	Good	Good
Facing bricks (pressed)	Medium	Medium	Good
Internal face			
Concrete blocks	Poor	Medium	Good
Aircrete	Medium	Poor	Good
Cavity insulation			
Mineral fibre	Poor	Poor	Poor
Blown-in expanded mica	Poor	Poor	Poor
Rigid PU foam	Medium	Medium	Good
Renders/Plaster			
Cement render – external	Good	Good	Good
Cement/lime render – external	Good	Good	Good
Gypsum Plasterboard	Poor	Not assessed	Poor
Lime plaster (young)	Poor	Not assessed	Poor

* Resilience characteristics are related to the testing carried out and exclude aspects such as ability to withstand freeze/thaw cycles, cleanability and mould growth

6.5.1 *Water exclusion strategy*

This strategy is applicable to design flood depths of up to 0.3m or up to 0.6m, if allowed by the structural assessment of the design.

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

Masonry walls:

Ensure mortar joints are thoroughly filled to reduce the risk of water penetration. If frogged bricks are used, they should be laid frog up so that filling becomes easier and coverage more certain. Bricks manufactured with perforations should not be used for flood resilient design.

Where possible, use engineering bricks up to predicted flood level plus one course of bricks to provide freeboard (up to maximum of 0.6m depth above floor level); this will increase resistance to water penetration. Blocks (and dense facing bricks) have much improved performance when covered with render.

Aircrete blocks allow less leakage than typical concrete blocks but concrete blocks dry more quickly. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a "water exclusion strategy", the expected amount of leakage is minimal and therefore, Aircrete blocks are recommended, although they may retain moisture for longer than concrete blocks, Compared with heavier blocks, Aircrete may offer less restraint to floor/slab edges which under the action of uplift forces could promote the opening up of floor/wall junctions.

Do not use highly porous bricks such as hand made clay bricks.

Solid masonry walls are a good option but will need to be fitted with internal or external wall insulation in order to comply with Building Regulations.

Clear cavity walls, i.e. with no insulation in the cavity, have better flood resilience characteristics than filled or part filled cavity walls as they dry more quickly. The requirements for insulation can be satisfied by external insulated renders or internal thermal boards.

There is evidence that thin layer mortar construction (or thin joint, as it is also commonly known) is a good flood resilience option.

Framed walls: Avoid timber framed walls containing construction materials that have poor performance in floods, for example oriented strand board and mineral fibre insulation. Timber framed walls are not recommended in a "water exclusion strategy". Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design, in particular with regard to the insulation.

Reinforced concrete wall/floor construction should be considered for flood-prone areas, i.e. where the frequency of flooding is predicted to be high (see Chapter 4). This form of construction is effective at resisting forces generated by floodwater and will provide an adequate barrier to water ingress (provided service ducts and other openings into the building are adequately sealed). Design details for this type of construction are beyond the scope of this document.

External renders are effective barriers to water penetration and should be used with blocks (or bricks) at least up to the predicted flood level plus the equivalent of a course of bricks as freeboard. Structural checks may be necessary to ensure stability, because of the external water pressures that could occur for design flood depths above 0.3m. External cement renders with lime content (in addition to cement) can induce faster surface drying.

Insulation:

External insulation is better than cavity insulation because it is easily replaced if necessary.

Cavity insulation should preferably incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

Internal linings:

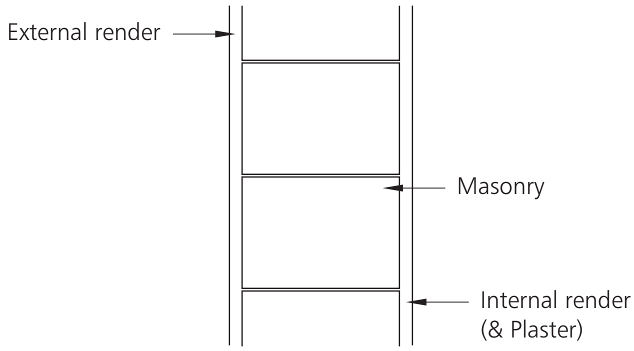
Internal cement renders (with good bond) are effective at reducing flood water leakage into a building and assist rapid drying of the internal surface of the wall. The extent to which render prevents drying of other parts of the wall is not currently clear. This may be important, particularly for solid wall construction. This applies also to external renders.

Avoid standard gypsum plasterboard as it tends to disintegrate when immersed in water. Splash proof boards do not necessarily offer protection against flood waters, which may remain for some time and exert pressure on the board.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6 months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

Examples of recommended wall arrangements are presented in Figures 6.7 to 6.9 below.

Figure 6.7 Solid External Walls



– External cement based render, preferably with lime content. Composition depends on masonry. The following mixes have good resilient properties:

1 cement : 6 sand on bricks;

1 cement : 4 sand: ½ lime on concrete blockwork or bricks;

1 cement : 6 sand: 1 lime on Aircrete blocks.

– Masonry with minimum thickness of 300mm (thin mortar joint construction using Aircrete blocks is effective as demonstrated in laboratory tests) or alternatively reinforced concrete wall

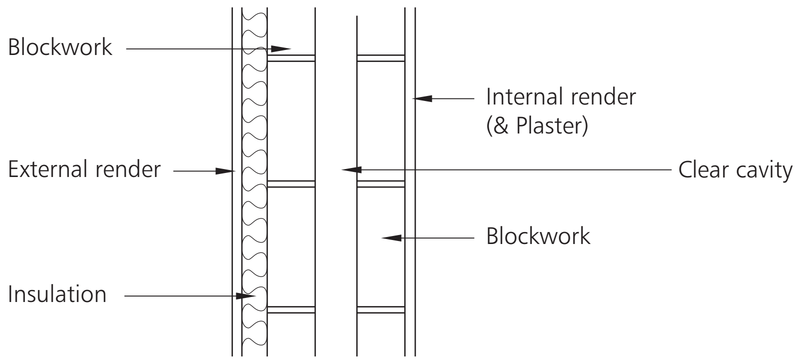
– Internal cement-based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:

1 cement : 6 sand: 1 lime on Aircrete.

Apply external and internal renders, following good practice guidance, ensuring minimum total thickness of 20mm and at least two coats.

– Use external insulation in preference to internal insulation.

Figure 6.8 Cavity External Walls – Clear cavity



<u>Clear cavity</u>

– External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective for flood resilience:

1 cement: 4 sand: ½ lime on concrete blockwork (or bricks);

1 cement: 6 sand: 1 lime on Aircrete.

Apply render following good practice guidance, ensuring minimum total thickness of 20mm and two coats.

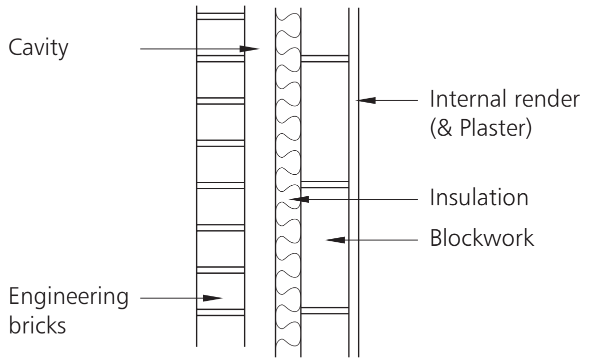
– Internal cement based render, preferably with lime content. Composition depends on masonry. The following mix works well:

1 cement: 6 sand: 1 lime on Aircrete.

– Stainless steel wall ties should be used to minimise corrosion and consequent staining.

Chapter 6

Figure 6.9 **Cavity External Walls – Part-filled cavity**

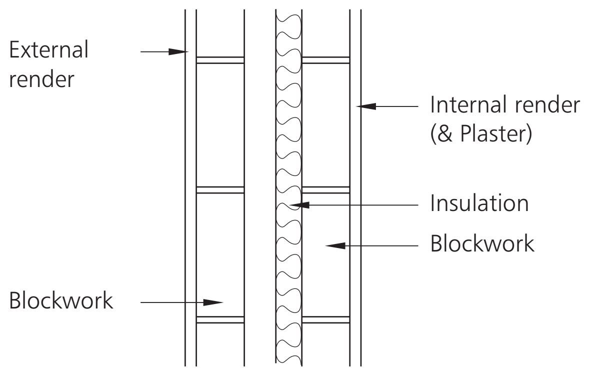


Option A Part-filled cavity

Part-filled cavity – Option A

- External face consisting of engineering bricks up to required level for flood protection (up to 0.6m maximum above floor level plus one course). Other external facing materials can be used above this level, but ensure interface is watertight.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:

    1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor and flood level. The board should be fitted horizontally to make removal easier. In some cases a dado rail can be used to cover the joints.



Option B

Part-filled cavity – Option B

- External cement based render, preferably with lime content. Composition depends on masonry; the following mixes are effective:

    1 cement : 4 sand: ½ lime on concrete blockwork

    1 cement : 6 sand: 1 lime on Aircrete.
- External face consisting of blocks.
- Rigid insulation.
- Internal face consisting of blocks.
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective for flood resilience:

    1 cement : 6 sand: 1 lime on Aircrete.
- Ensure stainless steel wall ties are used to minimise corrosion and consequent staining.

6.5.2 *Water entry strategy*

This strategy is applicable to design flood depths above 0.6m, or above 0.3m if the structural assessment of the design shows that the integrity of the building would be compromised by a "water exclusion strategy".

General advice for resilient design

Ensure high quality workmanship at all stages of construction.

<u>Masonry walls</u>:

Use good quality facing bricks for the external face of cavity walls.

Do not use soft bricks, such as hand made clay bricks, which can easily crumble when subjected to water.

Concrete blocks dry more quickly than Aircrete blocks. However, Aircrete blocks allow less leakage. Therefore, design of blockwork walls needs to take into account these two opposite types of behaviour and consider whether drying or resistance to water is most relevant in each situation. For a "water entry strategy" which is aimed at allowing water passage through the property, concrete blocks are recommended.

Clear cavity walls, i.e. with no insulation, have better resilience characteristics than filled or part filled cavity walls as they dry more quickly.

<u>Framed walls</u>: Avoid timber framed walls containing construction materials that have poor performance in floods, namely oriented strand board and mineral fibre insulation. Timber framed walls are generally not recommended, unless a sacrificial approach is adopted whereby some materials will be stripped to allow drying.

Steel framed walls may offer a suitable alternative option but specialist advice needs to be sought on how to incorporate resilient materials/construction methods in the design. The possible use of bituminous paint on steel plates may be a means of preventing corrosion.

<u>External renders</u> should not be used as they provide a barrier to water penetration and may induce excessive differences in depth between outside and inside of the property resulting in possible structural problems.

<u>Insulation</u>:

External insulation is better than cavity insulation because it is easily replaced if necessary; however it is generally protected by rigid lining which may create a barrier to water.

Cavity insulation should incorporate rigid closed cell materials as these retain integrity and have low moisture take-up. Other common types, such as mineral fibre batts, are not generally recommended as they can remain wet several months after exposure to flood water which slows down the wall drying process. Blown-in insulation can slump due to excessive moisture uptake, and some types can retain high levels of moisture for long periods of time (under natural drying conditions).

<u>Internal linings</u>:

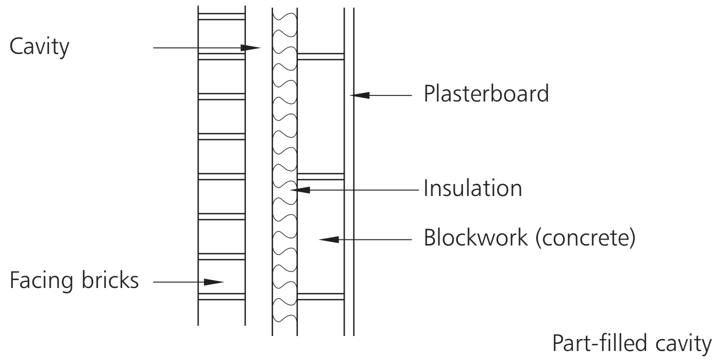
Avoid internal cement renders as these can prevent effective drying.

Use standard gypsum plasterboard up to the predicted flood level (plus freeboard of 50mm) as a sacrificial material. For this purpose, the use of a dado rail to separate the above and below flooded area may be useful. Splash proof boards do not necessarily offer better protection against flood waters, which may remain for some time and exert pressure on the board.

Above predicted flood level (plus freeboard) the use of plasterboard or internal cement renders is appropriate.

Anecdotal evidence suggests that internal lime plaster/render can be a good solution. Lime plaster depends on contact with the air to set and harden. Because of this, full strength lime plaster, which typically requires over 6months, was not possible to test. Consequently, no assurance can be given for its performance. Tests performed when young showed that it crumbles very easily under high water pressure.

Figure 6.10 Cavity External Walls – Part-filled cavity with sacrificial plasterboard



Part-filled cavity

- External face consisting of engineering bricks up to required level for flood protection (up to d.p.c.). Other external facing materials can be used above this level, but ensure transition is watertight.
- Rigid insulation
- Internal cement based render, preferably with lime content. Composition depends on masonry; the following mix is effective:

  1 cement : 6 sand: 1 lime on concrete blocks.
- Stainless steel wall ties should be used to minimise corrosion and consequent staining.
- Sacrificial plasterboard can be used, but it needs to be removed between ground floor to flood level. The board should be laid horizontally to make removal easier.

6.6 Doors and windows

Doors, windows and air vents are potential flow paths into properties.

General advice for resilient/resistant design

Doors: Raising the threshold as high as possible, while complying with level access requirements, should be considered as the primary measure. In addition, sealed PVC external framed doors should be used and, where the use of wooden doors is a preferred option, all effort should be made to ensure a good fit and seal to their frames.

Hollow core timber internal doors should not be used where the predicted frequency of flooding is high. Where sufficient flood warning is given, butt hinges, that allow internal doors to be easily removed and stored in dry areas prior to a flood, should be used. Where the frequency of predicted flooding is low or where there is no warning (e.g. overland or sewer flooding) it may be necessary to replace the doors after the flood.

Windows/patio doors: Windows and patio doors are vulnerable to flood water and similar measures to those used for doors should be taken. Special care should be taken to ensure adequate sealing of any PVC window/door sills to the fabric of the house. Of particular concern would be excessive water pressure on the glazing of patio doors. Double glazing conforming to the relevant standards would in principle adequately resist the pressures generated by flood waters; debris carrying flows may cause damage.

Air vents: special designs of air vent are available in the market to prevent water ingress in circumstances where the predicted flood depth is low (i.e. < 0.3m); e.g. periscopic air vent, see Figure 6.11. Careful consideration should be given to effectively sealing any associated joints.

Figure 6.11 **Periscopic air vent (courtesy Severn Trent Water)**

6.7 Fittings

6.7.1 Water exclusion strategy

General advice for resilient design

The main principle is to use durable fittings that are not significantly affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding.

Place fittings (e.g. electrical appliances, gas oven) on plinths as high as practicable above floor so that they are out of reach of flood water.

Ensure adequate sealing of joints between kitchen units and surfaces to prevent any penetration of water behind fittings.

Ensure high quality workmanship in the application of fittings.

An illustrative example of a resilient kitchen is given in Figure 6.12, e.g. raised oven and fridge/freezer on plinth and use of ceramic tiles on the floor. In this figure it can be seen that the kitchen units are made of stainless steel. Due to its relatively high cost this is a suitable solution only in cases where the predicted frequency of flooding is high (see Chapter 4).

More details are given in 'Standards for the repair of buildings following flooding' (CIRIA, 2005a) or in web sites such as the 'Guide to flood resilient repairs', promoted by Norwich Union (Norwich Union, web site).

Figure 6.12 **Main kitchen appliances (such as oven and fridge/freezer) placed above floor level (courtesy of Norfolk County Council and FLOWS Project)**

6.7.2 *Water entry strategy*

General advice for resilient design

Although a sacrificial approach can be adopted whereby fittings are designed to be replaced after a flood, it is advisable to specify durable fittings that are not appreciably affected by water and can be easily cleaned (e.g. use of plastic materials or stainless steel for kitchen units). The cost of these units may need to be balanced against the predicted frequency of flooding. Avoid wood fibre based carcases and use easily removable solid wood doors and drawers.

Place fittings (e.g. electrical appliances, gas oven) as high as practical above floor to minimise the risk of being affected by flood water.

When allowing water in, it is important to provide means for effective drainage and cleaning. Providing gaps behind kitchen units will facilitate drainage and will allow access for forced drying, if proved to be necessary.

Ensure high quality workmanship in the application of fittings.

More details are given in 'Standards for the repair of buildings following flooding' (CIRIA, 2005a) or in web sites such as the 'Guide to flood resilient repairs', promoted by Norwich Union (Norwich Union web site).

6.8 Services

General advice for resilient design

Where possible, all service entries should be sealed (e.g. with expanding foam or similar closed cell material).

Pipework: Closed cell insulation should be used for pipes which are below the predicted flood level.

Drainage services: Non-return valves are recommended in the drainage system to prevent back-flow of diluted sewage in situations where there is an identified risk of the foul sewer surcharging. Maintenance of these valves is important to ensure their continued effectiveness.

Water, electricity and gas meters: should be located above predicted flood level.

Electrical services: electrical sockets should be installed above flood level for ground floors to minimise damage to electrical services and allow speedy re-occupation (see Figure 6.13. Note a dado rail which provides a limit for replacement of any wall covering). Electric ring mains should be installed at first floor level with drops to ground floor sockets and switches.

Heating systems: boiler units and ancillary devices should be installed above predicted flood level and preferably on the first floor of two-storey properties. Underfloor heating should be avoided on ground floors and controls such as thermostats should be placed above flood level. Conventional heating systems, e.g. hot water pipes are unlikely to be significantly affected by flood water unless it contains a large amount of salts. The less common, hot air duct heating would remain effective provided it is installed above the design flood level.

Communications wiring: wiring for telephone, TV, Internet and other services should be protected by suitable insulation in the distribution ducts to prevent damage. Any proposed design solution for flood insulation on all potentially vulnerable wiring should be discussed with the relevant service providers.

Figure 6.13 **Raised sockets (courtesy of Norfolk County Council and FLOWS project); note also PVC skirting board and tiled floor**