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Flood resistant and resilient construction – Guide to improving the flood performance of buildings

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 30 November 2015. It was prepared by Technical Committee CB/501, *Flood risk and watercourses*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other documents

This British Standard is based upon the guide *Improving the flood performance of new buildings - flood resilient construction* published by the Department for Communities and Local Government in May 2007. It takes account of additional research into the reaction of modern materials and construction methods to flooding and has been extended to apply to retrofitting of flood resistance/resilience to existing buildings, as well as to new buildings. It provides greater detail than the core document of the same title that can be freely downloaded from <http://shop.bsigroup.com/BS85500>

Information about this document

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Use of this document

As a guide, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

Introduction

This British Standard is intended to help identify when flood resilient and resistant construction is appropriate and to give guidance on achieving these. This standard is applicable to new buildings, extensions and the retrofitting of existing properties.

National and local planning policies discourage inappropriate development in areas at risk of flooding. This standard does not promote development in flood risk areas, but provides guidance on reducing the potential consequences where buildings are located in an area at risk of flooding.

This standard is intended to help manage residual risk after other measures or approaches, such as avoiding risk, locating development in an area of low risk or raising floor levels (see 6.2), have been implemented.

1 Scope

This British Standard gives recommendations and guidance on how to improve the resistance and resilience of buildings to reduce the impacts of flooding from all sources, by the use of suitable materials and construction details. Specifically, it provides:

- a) recommendations for the adoption of flood resistant and resilient construction measures, including when to apply resistance and when to apply resilience; and
- b) guidance on the design and specification of flood resistance and resilience for new buildings, extensions and retrofits.

The guidance covers masonry, light-weight steel-frame and timber-frame buildings.

It is not applicable to:

- 1) the structural design or layout of buildings;
- 2) the selection, fixing and deployment of flood protection products which are covered by other standards, such as PAS 1188 and *Delivering benefits through evidence: Temporary and Demountable Flood Protection Guide* [1];
- 3) the design of watertight concrete, which is specified in BS EN 1992-3;
- 4) the construction of amphibious or floating properties;
- 5) the construction of properties on stilts; or
- 6) detailed avoidance measures outside the perimeter (footprint) of the building, such as local land raising above the predicted flood level.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 8102, *Code of practice for protection of below ground structures against water from the ground*

BS 8533, *Assessing and managing flood risk in development – Code of practice*

BS EN 13914-1, *Design, preparation and application of external rendering and internal plastering – Part 1: External rendering*

PAS 1188-1, *Flood protection products – Specification – Part 1: Building aperture products*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 flood avoidance

construction of a building and its surrounds in such a way as to avoid (at site level) it being flooded

EXAMPLES

Raising ground or floor level above the predicted flood level, re-siting outside flood risk area, landscaping to direct/divert flood water away from building, the use of bunds.

3.2 flood resistance

construction of a building in such a way as to prevent or minimize flood water entering the building and damaging its fabric

NOTE Also known as “dry-proofing”.

EXAMPLE

Use of low-permeability materials.

3.3 flood resilience

measures that can be incorporated into the building fabric and/or fixtures and fittings that can be installed to reduce the consequences of flood water entering the property

NOTE 1 This allows easier drying and cleaning following a flood and reduces the amount of time until the building can be reoccupied.

NOTE 2 Also known as “wet-proofing”.

EXAMPLES

Use of sacrificial materials for internal or external finishes, e.g. gypsum plasterboard placed so that it can easily be removed below the flooded level and replaced, or materials that can resist the effects of flooding, e.g. tiled finishes.

3.4 water entry strategy

design strategy based on allowing water to enter a property rather than preventing its ingress

3.5 water exclusion strategy

design strategy based on the use of impermeable materials to minimize the ingress of water into a property

4 Context

4.1 Resistance and resilience informed by flood risk assessment

National and local planning policies discourage inappropriate development in areas at risk of flooding. This British Standard does not promote development in flood risk areas, but provides guidance on reducing the potential consequences for buildings located in an area at risk of flooding.

The resistance and resilience measures recommended in this standard are based on a design strategy chosen in accordance with 6.1, which in turn should be informed by a site-specific flood risk assessment for the building or development site. These measures should only be applied after other measures, such as avoiding risk by locating development in an area of low risk or raising floor levels, have been implemented (see 6.2).

The flood risk assessment should be carried out in accordance with BS 8533. Key parameters of this assessment are the expected flood depth, duration and frequency, since these determine the likelihood of being able to keep water out of the building (resistance), and whether it is more cost-effective to plan for water ingress (resilience). In general terms, flooding associated with greater depths and longer durations requires the adoption of the water entry strategy, while shallow and short-duration flood water requires a water exclusion strategy and measures that do not need to be deployed by the householder. While the initial design strategy is based on the flooding characteristics, this might be changed subsequently to reflect the building construction type and performance requirements, the sensitivity of contents, the capability and circumstances of the householder, and the budget.

4.2 Types of flood and their characteristics

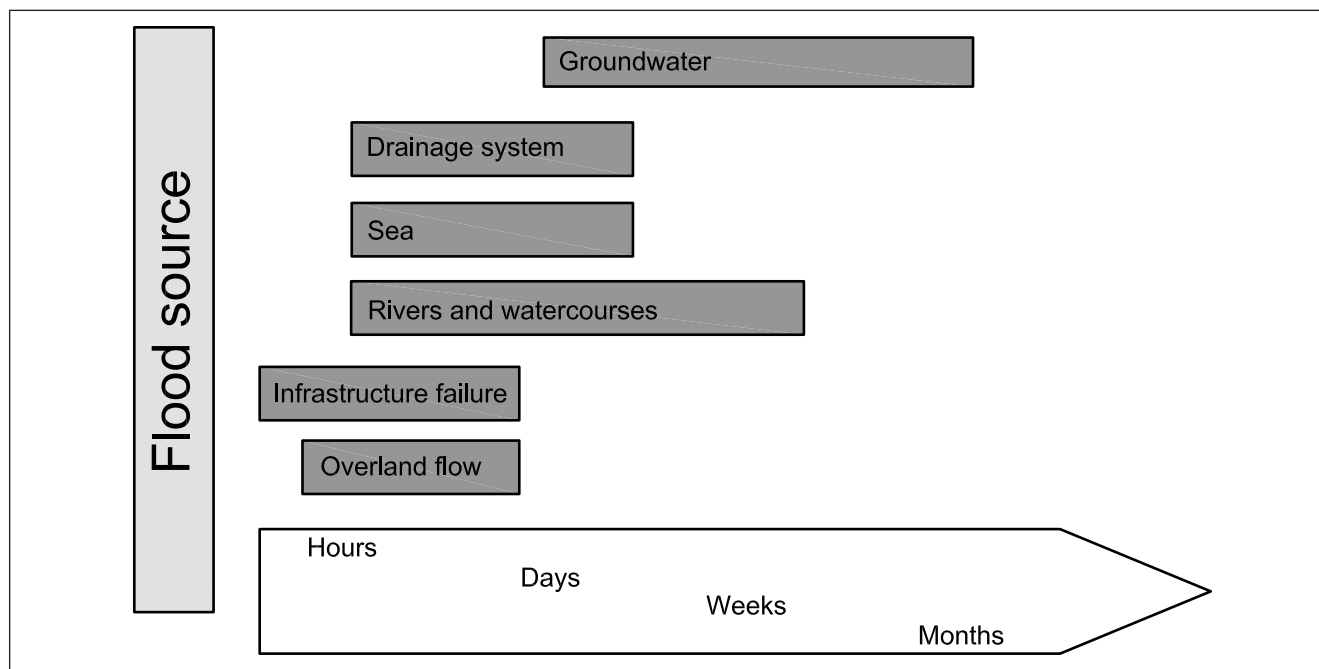
Figure 1 shows typical durations for different types of flooding.

Overland flow or exceedance of the sewerage infrastructure typically affects a property for up to a few days. However, in some areas the duration of flooding could be limited to only a few hours because the source of the flooding is an intense rainfall event. Such flooding would be expected to have a shallow depth. In contrast, groundwater is associated with extensive rainfall over a long period that has filled the available below-ground storage. Once established, this flooding can continue for many weeks or months. Although groundwater flooding affects fewer properties than other sources of flooding it often causes more damage. Failure of flood defences can result in significant flood depths and velocities in the zone immediately behind them, with impacts such as building damage or fatalities.

All of these flood characteristics (depth, duration and frequency of occurrence) are important in the choice of design strategy and the measures employed to deal with the flooding. However, although flooding can result from a single event or source, it more commonly occurs through a combination of events. Intense rainfall can lead to overland flow, but also cause watercourses to fill and overtop their banks. The flooding characteristics are determined as part of the site flood risk assessment (see 6.1).

If the likely flood depths (generally of existing properties) are determined to be high (>600 mm), a structural engineer should be consulted to assess the structural integrity of the building and potential strengthening measures.

Figure 1 Typical flood durations



4.3 Construction opportunities

New buildings should be located, designed and constructed such as to prevent them from being flooded, taking account of the type, depth, duration and frequency of flooding.

When any work is being undertaken on an existing building (including flood reinstatement), the opportunity should be taken to improve the flood resistance and resilience characteristics of the building, even if it has not been flooded but has been identified as at risk in the flood risk assessment.

An extension should provide at least the same level of flood resistance and resilience as the rest of the building, taking account of the flood risk assessment. However, where the existing building does not have the necessary level of flood resistance, as established from the flood risk assessment, the extension should be appropriately flood resilient. Ideally, flood resistance and resilience should be provided as part of the construction work, to allow for the resilience of the whole building to be improved over time as opportunities arise.

4.4 Other considerations

The design of flood resistance and resilience of a building needs to take account of the requirements of local planning (including listed building status, conservation areas and other designations), Building Regulations [2], [3] and [4] and health and safety. Existing construction and occupation types need to be considered.

5 Response of buildings

5.1 General

The impact of flood water on a building depends on the nature of the flooding and the design and construction of the property. In order to be able to improve the flood performance of the building it is first necessary to understand the impact of flooding on the materials, components and elements of the building. A risk-based approach can then be adopted.

Resistance and resilience measures are aimed at minimizing water entry and avoiding excessive damage to the building, respectively, and both can reduce disruption to the occupiers.

The impacts of flooding on buildings include the following:

- a) direct deterioration of materials, components and elements resulting in immediate change of their form and properties without returning to their previous condition after drying;
- b) direct structural damage caused by the depth, duration and velocity of flood waters on the building structure, including debris impact;
- c) inundation or saturation of materials that cannot be dried or recovered economically on site;
- d) temporary contamination of the internal and external surfaces, as well as cavities in walls and floors; and

NOTE 1 Temporary contamination by flood water does not normally represent a health hazard once dry and thoroughly cleaned as necessary.

- e) indirect secondary damage, such as mould growth and other problems arising from high atmospheric moisture.

NOTE 2 Secondary damage can be minimized by prompt action after an incident, especially drying measures.

Table 1 summarizes the potential flood impact on property, based upon depth and velocity, while Figure 2 demonstrates potential routes for entry of flood water into a dwelling.

Table 1 Possible flood damage for a typical residential property (1 of 2)

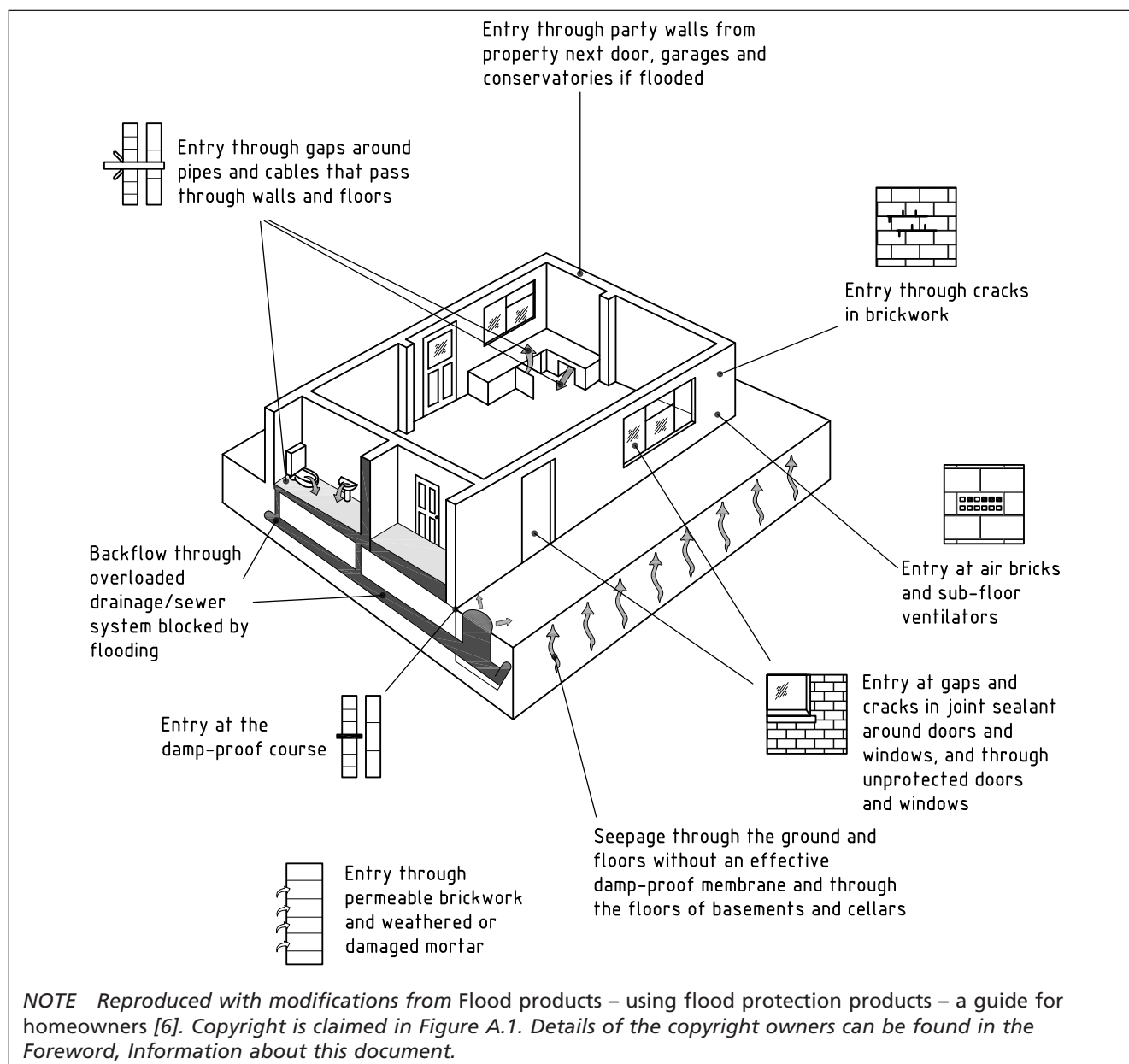
Flood water level	Damage to the building	Damage to services and fittings
Below door threshold level, e.g. basements	Where the basement is constructed for occupation: Deterioration of plaster, dry lining, composite and fibrous wall lining and flooring materials. Spoiling of decoration. Waterproofing measures designed to protect the basement from groundwater ingress can be affected. Open-cell and quilted insulation fitted to the internal walls can be damaged beyond economic repair. Pumping stations, sumps and channels associated with type C waterproofing are susceptible to blockage by silt and debris. Where the basement is unsuitable for occupation: Significant damage to the building's fabric is unlikely. However, timber and materials built onto or embedded within the walls are vulnerable to fungal decay if the surrounding masonry is not returned to a dry condition within a reasonable time.	Damage to electrical sockets, consumer units and utility meters. Warning Basements can be very rapidly inundated. Escape routes should be considered where there is a high risk of surface water flooding. Damage to fittings, wall and floor coverings.

Table 1 Possible flood damage for a typical residential property (2 of 2)

Flood water level	Damage to the building	Damage to services and fittings
Below door threshold level, e.g. basements	Sub-floor voids and subterranean slabs: Areas below the finished ground floor level might contain voids that can trap water. Failure to identify and remove this water could result in decay or deterioration in friable construction materials at or below the junction between the wall and floor. Mould and timber-decaying fungi can grow where damp conditions persist.	Floating, laminate or engineered floor finishes can swell or denature. MDF skirting boards, carpet gripper rods and other friable fittings can be denatured or affected by decay if exposed to damp conditions for protracted periods.
Shallow flooding	Build-up of water and silt in cavity walls, with potential reduction in the insulating properties of some materials. Damage to internal finishes, such as wall coverings, gypsum-based plaster and plasterboard dry linings. Timber-based materials exposed to water for protracted periods are likely to swell and crack, and warp if dried incorrectly. Damage to internal and external doors, skirting boards and other joinery timbers. Timber-decaying fungi and mould can develop unless water and humidity are correctly managed after flooding. Ground salts and other soluble contaminants present but immobile during dry periods can be put into solution during floods. Salts can be introduced by flood water after a single or repeated flooding event(s) (particularly seawater flooding). These can be transported through the fabric of solid walls to be deposited as hygroscopic contamination in wall finishes and plaster coats. Open-cell and quilted insulation within cavity walls can be damaged. In some circumstances it can retain water, impeding recovery. Corrosion of metal fixings and fittings.	Damage to electrical sockets, junction boxes, meters and gas meters. Damage to low-level gas boilers and some electrical underfloor heating systems. Damage to communication wiring and junction boxes. Carpets, laminate and composite floor coverings might need to be replaced. Kitchen units and bathroom cupboard carcasses made of chipboard and wood composite materials are likely to denature and might require replacement. Insulation on pipework might need to be replaced if not closed-cell type.
Deeper flooding	Increased damage to walls (as above). Differences in water levels greater than 600 mm across walls can cause structural damage through hydrostatic pressure. The likelihood of damage depends on the load characteristics, form of construction, size of unrestrained panels and materials used in the building. Damage to windows can be caused by relatively small differential pressures. High-speed flow around the building perimeter can lead to erosion of the ground surface. There is a potential risk of damage to the structure from large items of floating debris, e.g. tree trunks. Scouring to friable wall surfaces and soft mortar joints can occur during very high flow events.	As above. Damage to units, electrical services and appliances that are sited higher on the walls of the building.

NOTE Guidance on cleaning and drying is given in Public Health England's Floods – how to clean up your homes safely [5]. See also BS 12999.

Figure 2 Potential routes for entry of flood water into a dwelling



5.2 Foundations

Foundations are typically formed from concrete, masonry and steel, and do not usually suffer material damage due to flooding. However, erosion of ground due to flood water velocity can result in instability or settlement of the foundations. Granular soils might be at greater risk from scour than cohesive clay soils.

Figure 3, illustrating a ground bearing slab, shows a potential flow path from the ground adjacent and under a dwelling, through porous substructure and into the wall cavity. The figure highlights the fact that measures taken above ground level might not fully prevent the ingress of water.

Figure 4 illustrates flow paths for a suspended floor.

Figure 3 Water ingress into properties through the ground: Ground bearing floor

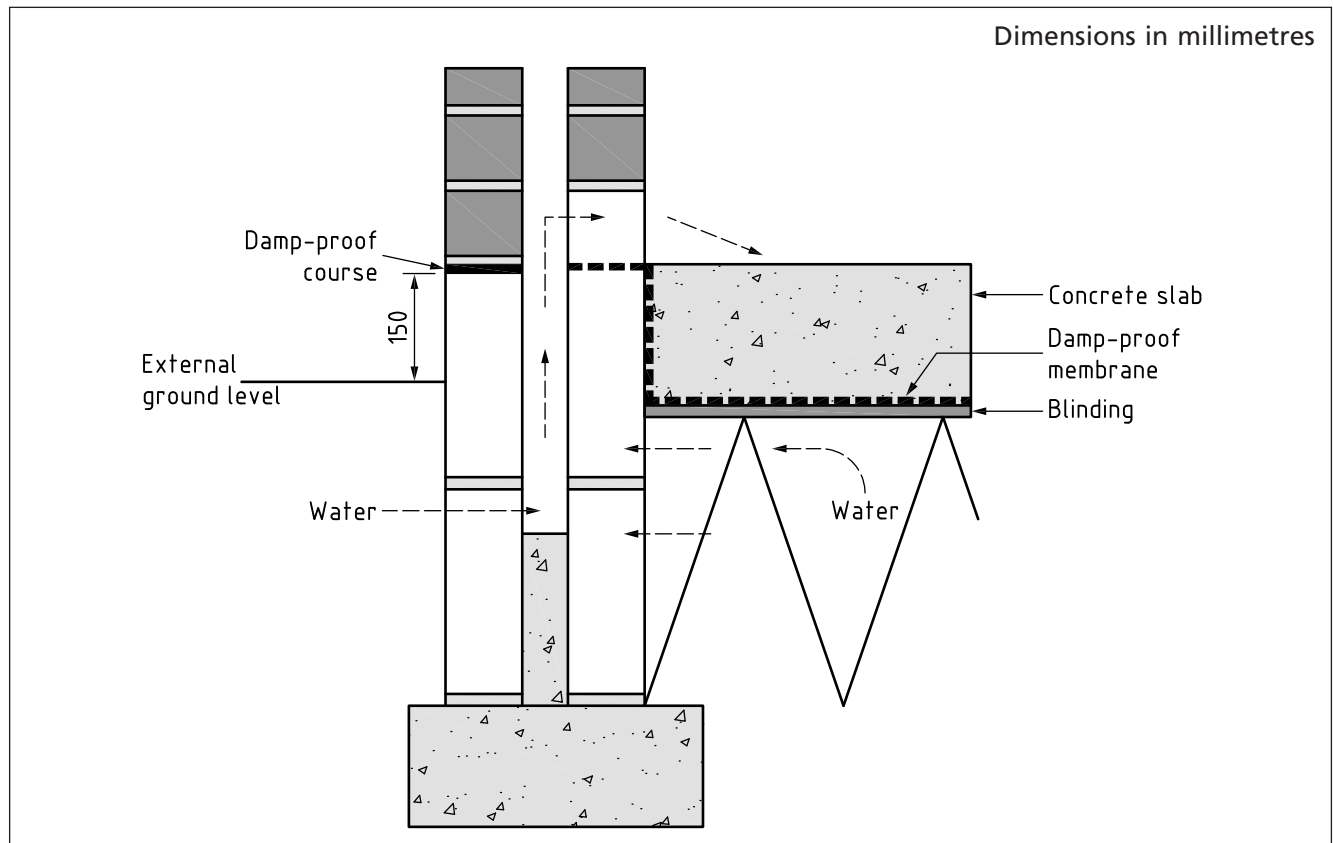


Figure 4 Water ingress into properties through the ground: Suspended floor

