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INSYDE: a synthetic, probabilistic flood damage model based on explicit cost analysis

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Hypotheses on damage mechanisms for the different building components

If the model is applied to calculate expected damages, the formulation for damage estimation to each building component *ij* can be written as:

$$C_{ij} = up_{ij} \cdot ext_{ij} \cdot E[R]$$

where up_{ij} is the unit price for the removal/replacement of the building component *ij* (default values are shown in Table S1 of this Supplement), ext_{ij} is the extension of the building component to be removed/replaced and *E[R]* is the expected damage ratio (see Section 2 of the manuscript).

A more general formulation is used to obtain a distribution of the total building damage, which takes into account the probabilities of occurrence of damage to the different components:

$$C_{ij} = up_{ij} \cdot ext_{ij} \cdot r_{ds}$$

where r_{ds} is the damage ratio of the element computed for damage state *ds*. Note that for some components, r_{ds} may depend on more than one hazard variable. Please refer to Section 2 of the main text for additional information.

In the description of damage functions, the general formulation will be used.

Clean-up costs

Pumping (C1)

The cost for water pumping is calculated by considering water volumes stored in the basement (if present) and in the part of building below ground level (if GL<0). The damage function is deterministic (see Section 2 of the main text).

$$ext_{C1} = IA \cdot (-GL) + BA \cdot (-BL)$$

$$C_{C1} = up_{C1} \cdot ext_{C1}$$

The basement level *BL* is calculated as $BL = GL - BH - 0.3$, where 0.3 m corresponds to the height of the slab.

Waste disposal (C2)

The cost for waste disposal are supposed to depend on water volumes stored in the first floor and in the basement (if present) and on sediment concentration *s*. In the case of contaminated water, waste disposal costs are incremented by 40%. The function is deterministic.

$$ext_{C2} = (IA \cdot h + BA \cdot BH) \cdot s$$

$$C_{C2} = \begin{cases} up_{C2} \cdot ext_{C2}, & q = 0 \\ 1.4 \cdot up_{C2} \cdot ext_{C2}, & q = 1 \end{cases}$$

Cleaning (C3)

Building surfaces that have been in contact with floodwaters should be cleaned. Cleaning costs are calculated by considering water depth, internal perimeter and internal floor area of each flooded storey, including the basement, if present. In the case of contaminated water, waste disposal costs are incremented by 40%. The function is deterministic.

$$ext_{C3} = (IP \cdot h + BA + BP \cdot BH + IA \cdot N_{FF})$$

$$C_{C3} = \begin{cases} up_{C3} \cdot ext_{C3}, & q = 0 \\ 1.4 \cdot up_{C3} \cdot ext_{C3}, & q = 1 \end{cases}$$

The number of flooded floors N_{FF} is a function of the water depth and the interfloor height of the building.

Dehumidification (C4)

Dehumidification costs appear for long duration floods and they are supposed to depend on building volume (function of the number of flooded floors, including the basement (if present)). The function is probabilistic (see Section 2 of the main text).

$$ext_{C4} = (IA \cdot IH \cdot N_{FF} + BA \cdot BH)$$

$$C_{C4} = up_{C4} \cdot ext_{C4} \cdot r_{ds}$$

The probability distribution of occurrence of damage related to flood duration is given by the fragility function shown in Figure S1.

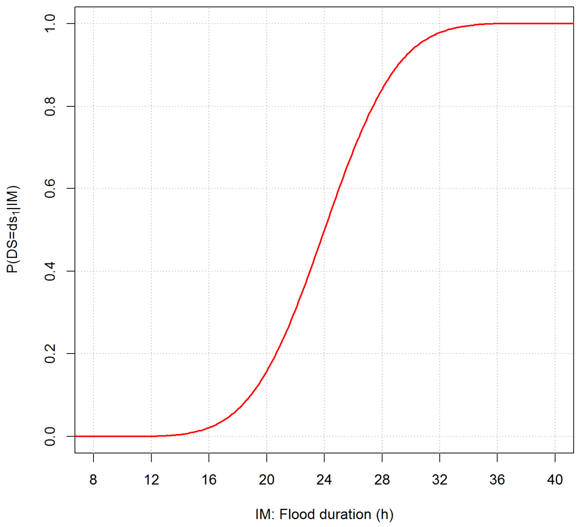

Figure S1: Fragility function for all applicable components, relative to flood duration.

Removal costs

Screed removal (R1)

Screed is considered to be removed in each flooded storey when the following conditions occur (Penning-Rowsell et al., 2005):

- type of pavement is wood: only high quality buildings (FL>1) are assumed to have wood pavements (otherwise, if not specifically indicated by the user, ceramic pavement is considered as the default condition);

- a full removal of wood pavements is necessary in each flooded storey; this is supposed to occur in case of long duration floods and high water levels, defined probabilistically in accordance with the fragility functions shown in Figure S1 and Figure S2, respectively.

$$ext_{R1} = IA \cdot N_{FF}$$

$$C_{R1} = up_{R1} \cdot ext_{R1} \cdot r_{ds}$$

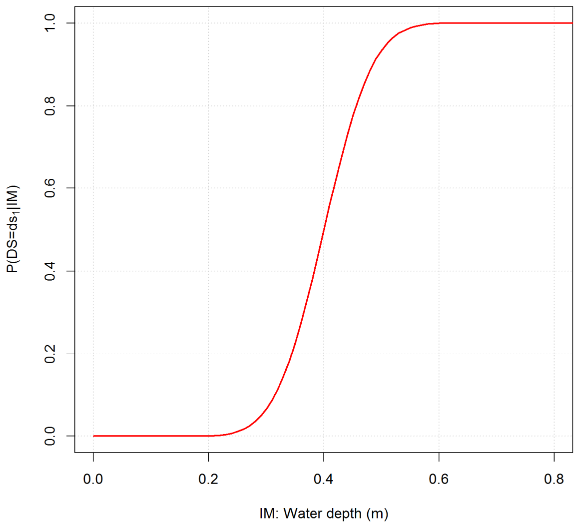

Figure S2: Fragility function for wood floors, relative to water depth in each flooded storey.

Pavement removal (R2)

Pavement removal is considered only when the type of pavement is "wood" (only high quality buildings (FL>1) are assumed to have wood pavements; otherwise, if not specifically indicated by the user, ceramic pavement is considered as the default condition). The function is probabilistic. A full removal of wood pavements in each flooded storey is considered when a long duration flood occurs, in accordance with the fragility function shown in Figure S1. The fragility function relative to water depth in each flooded storey is shown in Figure S2.

$$ext_{R2} = IA \cdot N_{FF}$$

$$C_{R2} = up_{R2} \cdot ext_{R2} \cdot r_{ds}$$

Baseboard removal (R3)

Baseboard is considered to be removed when a long flood duration occurs and h>0.05 m in each flooded storey (Penning-Rowsell et al., 2005). The function is probabilistic. The fragility function relative to flood duration is shown in Figure S1.

$$ext_{R3} = IP \cdot N_{FF}$$

$$C_{R3} = up_{R3} \cdot ext_{R3} \cdot r_{ds}$$

Removal of partition walls (R4)

Damage to partition walls is due to absorbed water that cannot be dried up. The function is probabilistic. Damage is supposed to appear for long duration floods in accordance with the fragility function shown in Figure S1, and for water depths defined by the fragility function shown in Figure S3. If not specifically indicated, the perimeter of partition walls is supposed to be equal to the 50% of the internal perimeter (this value is incremented by 20% for reinforced concrete structures, in order to account for external walls).

$$ext_{R4} = \begin{cases} 0.5 \cdot IP \cdot IH \cdot N_{FF}, & BS = 2 \\ 1.2 \cdot 0.5 \cdot IP \cdot IH \cdot N_{FF}, & BS = 1 \end{cases}$$

$$C_{R4} = up_{R4} \cdot ext_{R4} \cdot r_{ds}$$

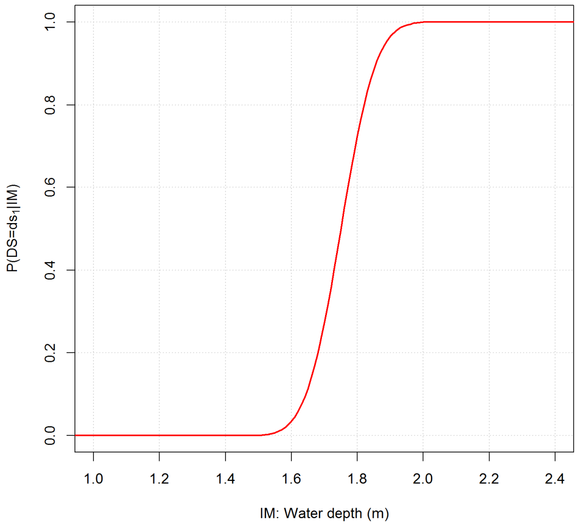

Figure S3: Fragility function for partition walls relative to water depth in each flooded storey.

Plasterboard removal (R5)

If not specifically indicated, only high quality buildings (FL>1) are assumed to have plaster ceilings, placed 0.5 m below the original ceiling level. Plasterboard area is assumed to be equal to the 20% of the internal area of the building. Plasterboard is considered to be removed when flood depth reaches plaster ceiling level. The function is deterministic.

$$ext_{R5} = 0.2 \cdot IA \cdot N_{FF}$$

$$C_{R5} = up_{R5} \cdot ext_{R5}$$

External plaster removal (R6)

External plaster is considered to be removed if one (or more) of these conditions occur (Penning-Rowsell et al., 2005):

- long duration flood: longer residence time enhances water penetration into the plaster; the fragility function is shown in Figure S1;
- high velocity flow: higher flow velocities cause more serious damage to exterior plaster; the fragility function is shown in Figure S4;
- contaminated water (q=1): plaster replacement is usually required in case of contaminated water; in such scenarios, the damage ratio is considered to be 1;
- level of maintenance is "average" or "poor" (i.e. LM≤1), which implies a more vulnerable plaster, even under short duration floods and/or absence of contaminants in the water. For those building maintenance levels, the damage ratio is considered to be 1.

The function is probabilistic. If more than one of the conditions mentioned above occur, the damage ratio considered is the maximum among the four. The underlying assumption is that the most unfavourable condition dominates the damage mechanism, independently of the others. The height considered in the calculations for plaster removal is equal to the external water depth plus 1.0 m due to capillary rise.

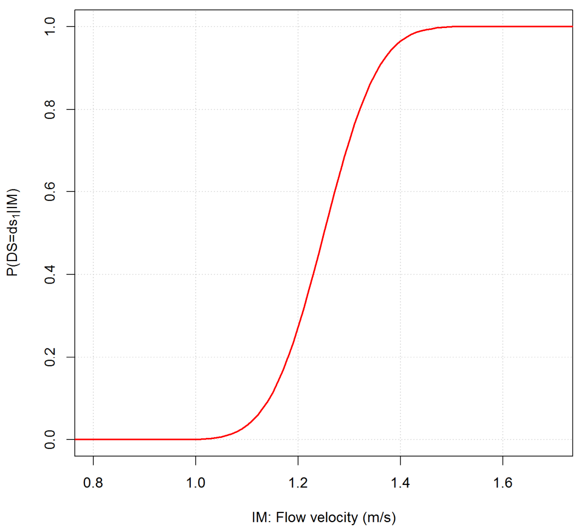

Figure S4: Fragility function for external plaster and doors relative to flow velocity.

$ext_{R6} = EP \cdot (h_e + 1.0)$

$C_{R6} = up_{R6} \cdot ext_{R6} \cdot \max(r_{ds})$

Internal plaster removal (R7)

Internal plaster is considered to be removed if one (or more) of these conditions occur (Penning-Rowsell et al., 2005):

- long duration flood: longer residence time enhances water penetration into the plaster; the fragility function is shown in Figure S1;
- contaminated water (q=1): plaster replacement is usually required in case of contaminated water; in such scenarios, the damage ratio is considered to be 1;
- level of maintenance is "average" or "poor" (i.e. LM≤1), which implies a more vulnerable plaster, even under short duration floods and/or absence of contaminants in the water. For those building maintenance levels, the damage ratio is considered to be 1.

The function is probabilistic. If more than one of the conditions mentioned above occur, the damage ratio considered is the maximum among the three. The underlying assumption is that the most unfavourable condition dominates the damage mechanism, independently of the others.

The height considered in the calculations for plaster removal is equal to the internal water depth plus 1.0 m due to capillary rise.

$ext_{R7} = IP \cdot (h + 1.0) + BP \cdot BH$

$C_{R7} = up_{R7} \cdot ext_{R7} \cdot \max(r_{ds})$

Doors removal (R8)

Doors are more likely to require removal with higher water depths in each flooded storey, in accordance with the fragility function shown in Figure S5, and when at least one of these conditions is met (Penning-Rowsell et al., 2005):

- long duration flood: doors may swell under a long contact with water; the fragility function is shown in Figure S1;
- high velocity flow: doors can be seriously damaged under high velocity flows; the fragility function is shown in Figure S4.

The function is probabilistic. If more than one of the conditions mentioned above occur, the damage ratio considered is the maximum among the two. The underlying assumption is that the most unfavourable condition dominates the damage mechanism, independently of the other.

As default, the number of doors in each building is supposed to depend on the floor level (2 doors per 100 m^2 if the use is "basement", 7 doors per 100 m^2 for other storeys). If not specifically indicated, a standard door size is considered (0.8 x 2.1 m).

$$ext_{R8} = 0.12 \cdot IA \cdot N_{FF} + 0.03 \cdot BA$$

$$C_{R8} = up_{R8} \cdot ext_{R8} \cdot \max(r_{ds})$$

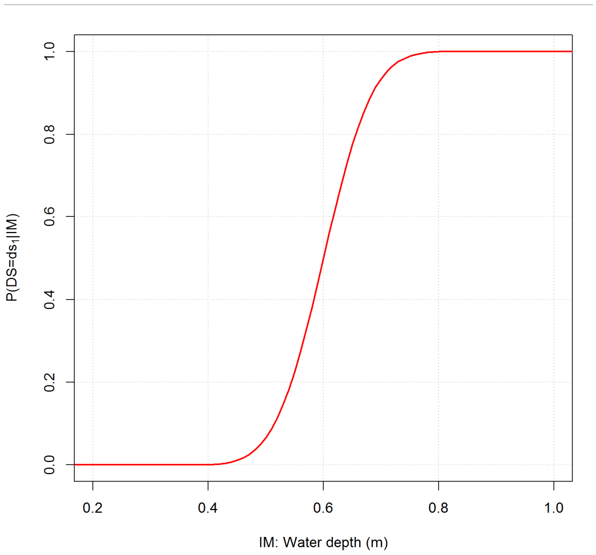

Figure S5: Fragility function for doors relative to water depth in each flooded storey.

Windows removal (R9)

Windows are more likely to require removal with higher water depths in each flooded storey, in accordance with the fragility function shown in Figure S6, and when at least one of these conditions is met:

- long duration flood: windows may swell under a long contact with water; the fragility function is shown in Figure S1;
- high velocity flow: windows can be seriously damaged under high velocity flows; the fragility function is shown in Figure S7.

The function is probabilistic. If more than one of the conditions mentioned above occur, the damage ratio considered is the maximum among the two. The underlying assumption is that the most unfavourable condition dominates the damage mechanism, independently of the other.

As default, the number of windows in each building is supposed to depend on the floor level (0 if "basement", 6 windows per 100 m^2 for other storeys). If not specifically indicated, a standard window size is considered (1.4 x 1.4 m).

$$ext_{R9} = 0.12 \cdot IA \cdot N_{FF}$$

$$C_{R9} = up_{R9} \cdot ext_{R9} \cdot \max(r_{ds})$$

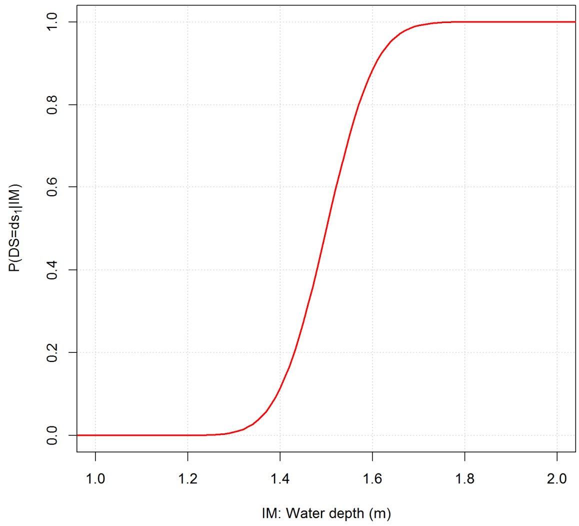

Figure S6: Fragility function for windows relative to water depth in each flooded storey.

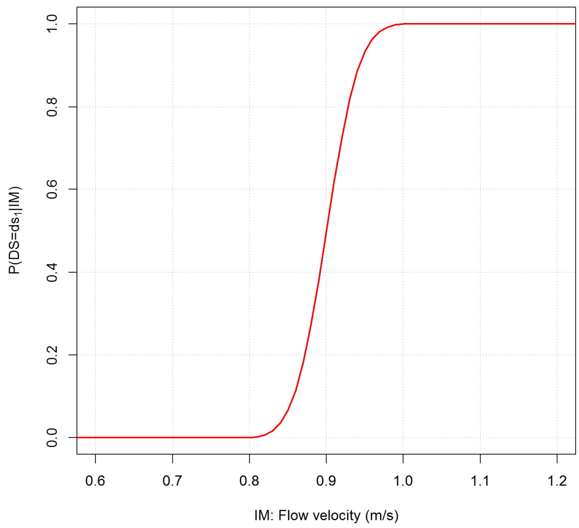

Figure S7: Fragility function for windows relative to flow velocity.

Boiler removal (R10)

The function is deterministic. In the case of distributed heating systems (PD=2), the boiler is considered to be removed when h>1.6 m in each flooded storey (boiler is supposed to be placed at +1.60 m from the pavement level), while for centralised heating systems two conditions are possible:

1) if a basement exists (i.e. BA>0), the boiler room is supposed to be located in the basement: the boiler is always considered to be removed when there is an event (i.e. basement is completely flooded);
2) if a basement is not present (i.e. BA=0), the boiler room is supposed to be located in the ground/first floor: in that case, the boiler is considered to be replaced for h>1.6 m.

$$ext_{R10} = \begin{cases} IA \cdot N_{FF}\,, & h > 1.6\,m\ \ (when\ PD = 2) \\ IA\,, & h > 0\,m\ \ (when\ PD = 1\ and\ BA > 0) \\ IA\,, & h > 1.6\,m\ \ (when\ PD = 1\ and\ BA = 0) \\ 0, & else \end{cases}$$

$$C_{R10} = up_{R10} \cdot ext_{R10}$$

Non-structural damage

Partitions replacement (N1)

The quantity of removed partitions is replaced (see function R4).

$$ext_{N1} = ext_{R4}$$

$$C_{N1} = up_{N1} \cdot ext_{R4} \cdot r_{ds}$$

Screed replacement (N2)

The quantity of removed screed is replaced (see function R1).

$$ext_{N2} = ext_{R1}$$

$$C_{N2} = up_{N2} \cdot ext_{N2} \cdot r_{ds}$$

Plasterboard replacement (N3)

The quantity of removed plasterboard is replaced (see function R5).

$$ext_{N3} = ext_{R5}$$

$$C_{N3} = up_{N3} \cdot ext_{N3}$$

Structural damage

In this version of INSYDE, structural damage is modelled probabilistically using a simple scheme, based on the approach proposed by Clausen and Clark (1990). Two damage classes (i.e. *Inundation* and *Partial damage*) are distinguished based on specific thresholds for flow velocity and intensity (i.e. the product between external flood depth and velocity) (Figure S8):

- *Inundation* ($v \leq 2$ m/s or $v \cdot he \leq 3$ m^2/s): no structural damages occur (i.e. the damage ratio is zero);
- *Partial damage* ($v > 2$ m/s and $3 < v \cdot he \leq 7$ m^2/s): some damages to the major structural elements of the building may occur, including soil consolidation, local repair and pillar repair. The fragility function is given in Figure S8.

At present, INSYDE does not consider the building collapse (which is very unlikely in the case of riverine floods, especially for reinforced concrete and masonry buildings), so the third damage class proposed by Clausen and Clark (1990) (*Total destruction*) is not implemented in the model.

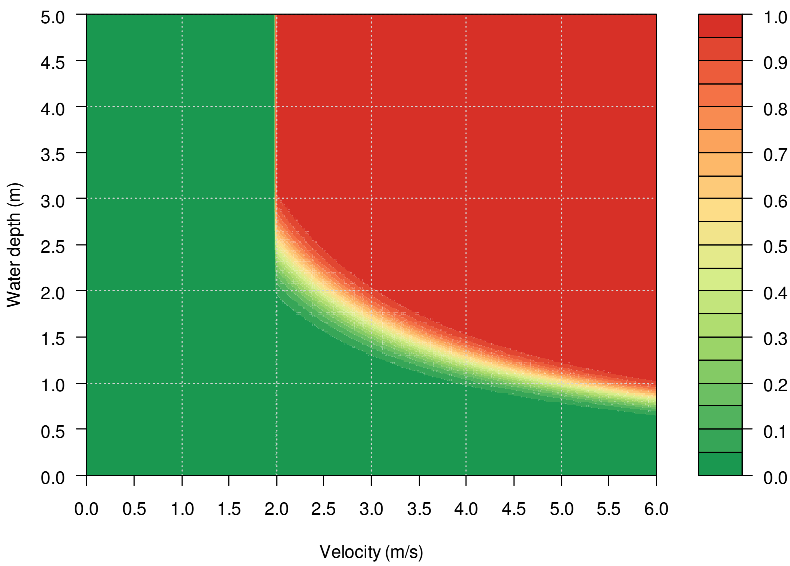

Figure S8: Fragility function for structural components relative to flow velocity and water depth.

Soil consolidation (S1)

Flood action may produce some scour near building foundations. The costs for soil consolidation are supposed to depend on building structure and on a fraction of building volume. In particular, if building structure is "Masonry" (BS=2), the volume of soil to be consolidated is considered to be equal to building volume, multiplied by 0.01; if building structure is "reinforced concrete" (BS=1), the multiplying coefficient is 0.02. These coefficients should be validated, as they should also depend on soil type, building shape and foundation type.

$$ext_{S1} = \begin{cases} IA \cdot NF \cdot IH \cdot 0.01, & BS = 2 \\ IA \cdot NF \cdot IH \cdot 0.02, & BS = 1 \end{cases}$$

$$C_{S1} = up_{S1} \cdot ext_{S1} \cdot r_{ds}$$

Local repair (S2)

Flood action may cause some damage on the external structure of masonry buildings. So, if building structure is "Masonry" (BS=2), local repair costs are considered to be a function of external water depth, sediment load and external perimeter of the building, under the assumption that only two sides of the building may be exposed to flow and that a scour depth of 0.05 m in the masonry should be repaired.

$$ext_{S2} = 0.5 \cdot EP \cdot h_e \cdot 0.05 \cdot (1 + s)$$

$$C_{S2} = up_{S2} \cdot ext_{S2} \cdot r_{ds}$$

Pillar repair (S3)

Flood action may cause some damage on the pillars of reinforced concrete buildings. So, if building structure is "Reinforced concrete" (BS=1), the costs for pillar repair are considered to be a function of external water depth, sediment load and external perimeter of the building (under the assumption that the total perimeter of pillars is equal to the 15% of the external perimeter of the building and that only two sides of the building may be exposed to flow).

$$ext_{S3} = 0.5 \cdot 0.15 \cdot EP \cdot h_e \cdot (1 + s)$$

$$C_{S3} = up_{S3} \cdot ext_{S3} \cdot r_{ds}$$

Finishing

External and internal plaster replacement (F1 and F2)

If removed, external and internal plaster are replaced (see function R6 and R7). These costs are supposed to depend on finishing level FL (i.e. higher quality plaster in high quality buildings). The function is probabilistic.

$$ext_{F1} = ext_{R6}$$

$$C_{F1} = up_{F1} \cdot ext_{F1} \cdot \max(r_{ds}) \cdot FL$$

$$ext_{F2} = ext_{R7}$$

$$C_{F2} = up_{F2} \cdot ext_{F2} \cdot \max(r_{ds}) \cdot FL$$

External painting (F3)

The extension of the external area to be repainted is considered to be a function of the height of flooded floors and the external perimeter. The costs for external painting are supposed to depend on finishing level FL (i.e. higher quality painting in high quality buildings). The function is deterministic.

$$ext_{F3} = EP \cdot N_{FF} \cdot IH$$

$$C_{F3} = up_{F3} \cdot ext_{F3} \cdot FL$$

Internal painting (F4)

The costs for internal painting are considered to depend on finishing level and building type. They are calculated by considering the height of flooded floors and the internal perimeter. The contribution of the basement is considered only in the case of high-quality detached houses (i.e. FL>1 and BT=1), while in the other cases the basement is assumed to be only plastered (no need for internal basement repainting). The function is deterministic.

$$ext_{F4} = \begin{cases} IP \cdot N_{FF} \cdot IH, & FL \leq 1 \\ IP \cdot N_{FF} \cdot IH + BP \cdot BH, & FL > 1 \ and \ BT = 1 \end{cases}$$

$$C_{F4} = up_{F4} \cdot ext_{F4} \cdot FL$$

Pavement replacement (F5)

If removed, pavement (see function R2) is replaced. The function is probabilistic.

$$ext_{F5} = ext_{R2}$$

$$C_{F5} = up_{F5} \cdot ext_{F5} \cdot r_{ds}$$

Baseboard replacement (F6)

The quantity of removed baseboard is replaced (see function R3). The function is probabilistic.

$$ext_{F6} = ext_{R3}$$

$$C_{F6} = up_{F6} \cdot ext_{F6} \cdot r_{ds}$$

Windows and doors

Doors and windows replacement (W1 and W2)

If removed, doors and windows are replaced (see functions R8 and R9). When FL>1, the costs for doors and windows replacement are increased by a factor depending on FL. The function is probabilistic.

$$ext_{W1} = ext_{R8}$$

$$C_{W1} = \begin{cases} up_{W1} \cdot ext_{W1} \cdot \max(r_{ds}), & FL \leq 1 \\ 2 \cdot up_{W1} \cdot ext_{W1} \cdot \max(r_{ds}), & FL > 1 \end{cases}$$

$$ext_{W2} = ext_{R9}$$

$$C_{W2} = \begin{cases} up_{W2} \cdot ext_{W2} \cdot \max(r_{ds}), & FL \leq 1 \\ 2 \cdot up_{W2} \cdot ext_{W2} \cdot \max(r_{ds}), & FL > 1 \end{cases}$$

Building systems

Boiler replacement (P1)

If removed, the boiler is replaced (see function R10). The function is deterministic.

If building type is "detached" or "semi-detached" (BT=1 or BT=2), costs are increased by 25% (as the boiler is generally over dimensioned in these cases).

$$ext_{P1} = ext_{R10}$$

$$C_{P1} = \begin{cases} 1.25 \cdot up_{P1} \cdot ext_{P1}, & BT = 1 \ or \ 2 \\ up_{P1} \cdot ext_{P1}, & BT = 3 \end{cases}$$

Radiator painting (P2)

If the heating system type is "Radiator" (PT=1), radiator painting is supposed to be required only when h>0.20 m in each flooded storey. One radiator per 20 m^2 of building internal floor area is considered. The function is deterministic.

$$ext_{P2} = N_{FF} \cdot IA/20$$

$$C_{P2} = up_{P2} \cdot ext_{P2}$$

Replacement of the underfloor heating system (P3)

The underfloor heating system (i.e. PT=2) is considered to be replaced only when also the screed needs to be removed (see function R1). The function is probabilistic. The fragility function related to flood duration in the case of wood pavement is given in Figure S1.

$$ext_{P3} = IA \cdot N_{FF}$$

$$C_{P3} = up_{P3} \cdot ext_{P3} \cdot r_{ds}$$

Electrical system replacement (P4)

Damages to the electrical system are considered exclusively dependant on water depth. Four different classes are distinguished for each flooded storey:

- for h < 0.20 m, the electrical system is not damaged;
- for 0.20m ≤ h < 1.10 m, lower sockets and cables are damaged, assuming a 40% relative damage;
- for 1.10m ≤ h < 1.50 m, upper sockets and cables are also damaged, assuming a 70% relative damage;
- for h ≥ 1.50 m, control panel is also damaged, assuming a 100% relative damage.

$$ext_{P4} = \begin{cases} 0\,, & h \leq 0.2\ m \\ 0.4 \cdot IA \cdot N_{FF}\,, & 0.2 < h < 1.1\ m \\ 0.7 \cdot IA \cdot N_{FF}\,, & 1.1 \leq h < 1.5\ m \\ IA \cdot N_{FF}\,, & h \geq 1.5\ m \end{cases}$$

The function is deterministic. An incremental coefficient is introduced for FL>1, in order to take into account the presence of more sophisticated systems (e.g. presence of security alarm systems, home automation systems, etc.) in high quality buildings.

$$C_{P4} = \begin{cases} up_{P4} \cdot ext_{P4}\,, & FL \leq 1 \\ 2 \cdot up_{P4} \cdot ext_{P4}\,, & FL > 1 \end{cases}$$

Plumbing system replacement (P5)

Damages to the plumbing system are supposed to occur if the sediment load is relevant (i.e. s>0.10) or if water is contaminated (q=1). Under these conditions, plumbing system is supposed be obstructed and/or damaged.

For what concerns the influence of water depth, four different classes are distinguished:

- for h ≤ 0.15 m, the plumbing system is not damaged;
- for 0.15m < h < 0.40 m, the shower can be damaged, assuming a 10% relative damage;
- for 0.40m ≤ h < 0.90 m, toilet bowl and bidet can also be damaged, assuming a 30% relative damage;
- for h ≥ 0.90 m, sinks can be damaged, assuming a 50% relative damage.

$$ext_{P5} = \begin{cases} 0\,, & h \leq 0.15\ m \\ 0.1 \cdot IA \cdot N_{FF}\,, & 0.15 < h < 0.4\ m \\ 0.3 \cdot IA \cdot N_{FF}\,, & 0.4 \leq h < 0.9\ m \\ 0.5 \cdot IA \cdot N_{FF}\,, & h \geq 0.9\ m \end{cases}$$

The function is deterministic. An incremental coefficient is introduced for FL>1, in order to take into account the presence of more sophisticated systems in high quality buildings.

$$C_{P5} = \begin{cases} up_{P5} \cdot ext_{P5}\,, & FL \leq 1 \\ 2 \cdot up_{P5} \cdot ext_{P5}\,, & FL > 1 \end{cases}$$

Components	Subcomponents	Unit of measurement	Default value
Clean-up	C1 - Pumping of water	€/m^3 of water	2.50
	C2 -Waste disposal	€/m^3 of waste	35.00
	C3 - Cleaning	€/m^2 of surface to be cleaned	2.40
	C4 - Dehumidification	€/m^3 of building volume	5.00
Removal	R1- Screed removal	€/m^2 of building area	11.80
	R2 - Pavement (wood)	€/m^2 of building area	6.20
	R3 - Baseboard	€/m of baseboard	0.63
	R4 - Partitions	€/m^2 of wall	14.90
	R5- Plasterboard	€/m^2 of plasterboard	11.80
	R6 - External plaster	€/m^2 of wall	7.10
	R7 - Internal plaster	€/m^2 of wall	7.10
	R8 - Doors	€/m^2 of door surface	21.10
	R9 - Windows	€/m^2 of window surface	21.10
	R10 - Boiler	€/m^2 of building area	0.25
Non-structural	N1 - Partitions replacement	€/m^2 of wall	67.20
	N2 - Screed replacement	€/m^2 of building area	18.70
	N3 - Plasterboard replacement	€/m^2 of plasterboard	45.50
Structural components	S1 - Soil consolidation	€/m^3 of soil	290.00
	S2 - Local repair	€/m^2 of masonry	37.50
	S3 - Pillar repair	€/m^2 of pillar surface	320.00
Finishing	F1 - External plaster replacement	€/m^2 of wall	27.50
	F2 - Internal plaster replacement	€/m^2 of wall	25.30
	F3 - External painting	€/m^2 of wall	10.30
	F4 - Internal painting	€/m^2 of wall	8.10
	F5 - Pavement replacement (wood)	€/m^2 of building area	113.00
	F6 - Baseboard replacement	€/m of baseboard	2.40
Windows & doors	W1 - Doors replacement	€/m^2 of door surface	195.00
	W2 - Windows replacement	€/m^2 of window surface	268.50
Plants	P1 - Boiler replacement	€/m^2 of building area	17.80
	P2 - Radiator painting	€/item	62.00
	P3 - Underfl. heat. sys. replacement	€/m^2 of building area	72.00
	P4 - Electrical system replacement	€/m^2 of building area	42.90
	P5 - Plumbing system replacement	€/m^2 of building area	28.90

Table S1. Unit of measurement and default unitary prices for damage estimation at the different building subcomponents.

Assumptions on Unit Prices: economies of scale

When building type is “Apartment house” (BT=3), removal/replacement prices for the different components are reduced by 20% due to economies of scale.

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