Technical note 2016/01 Condensation risk analysis of elements in contact with the ground

JPA|TL

This technical note describes how to configure JPA Designer to carry out condensation risk analysis for solid and suspended ground floors, basement floors and basement walls.

This is the second edition of the note which replaces the first edition.

1   Background

The methods used to calculate U-values for elements in contact with the ground, such as solid ground floors and basement walls, which are defined in BS EN ISO 13370, are not compatible with condensation risk analysis carried out to BS EN ISO 13788.

U-value calculations to BS EN ISO 13370 account for the thermal resistance of the ground by equations which give an annual, average thermal resistance based on the perimeter/ area ratio of the floor, the wall thickness and the conductivity of the ground. Analysis to BS EN ISO 13788 requires a series of layers, each with a thermal resistance and a vapour resistance: as the BS EN ISO 13370 U-value calculation does not include those layers it cannot be used as the basis for condensation risk analysis.

JPA Designer therefore does not permit condensation risk analysis to be carried out on elements which use the BS EN ISO 13370 method, namely: solid and suspended ground floors, basement floors and basement walls. This technical note describes how to adapt JPA Designer's standard wall and non-ground floor calculations to carry out condensation risk analysis for elements in contact with the ground.

2   The effect of the ground on condensation risk analysis

Analysis of ground bearing floors and walls – solid ground floors, basement floors and basement walls – must take account of the effect of the ground on the temperature of

the element. The analysis must use an external temperature which represents the below ground temperature, and an external relative humidity of 100%. The method for determining the temperature is described in section 3 and subsection 3.1. The model in JPA Designer must also include a layer for the ground. This is described in subsection 4.1.

Analysis of suspended ground floors is only concerned with conditions within the floor deck and therefore does not need to take any account of the ground. The ventilation to the subfloor void, intended to remove the risk of damage from ground moisture, allows us to treat the void as having the same humidity level as outside air, with the temperature being somewhere between the internal and external temperatures. as we are only concerned with condensation risk within the deck: ventilation to the subfloor void is designed to eliminate the risk of damaging moisture elsewhere in the construction. The method for determining the temperature is described in section 3 and subsection 3.2, while subsection 4.2 explains how to set up the calculation correctly in JPA Designer.

3 Environmental conditions

Table 1: External environmental conditions

Construction	External relative humidity	External temperature
Solid ground floor	100% all months	Mean ground temperature
Suspended ground floor	As external air	Mean subfloor temperature
Basement floor	100% all months	Mean ground temperature
Basement wall	100% all months	Mean ground temperature

The internal environmental conditions – monthly average temperature and relative humidity - are set in the normal way. In most cases the internal relative humidity is based on the external relative humidity but adjusted by a moisture load derived from the humidity class. In practice, this will require additional steps in the calculation process to set these levels correctly.

The external conditions are more difficult, as for ground-bearing constructions the ground temperature will not be the same as the external air temperature, and for suspended floors the subfloor temperature will not be the same as the external air temperature. The requirements for external conditions are summarised in Table 1. The method for calculating the ground temperature is described in subsection 3.1 and the method for the subfloor void temperature in subsection 3.2.

3.1 Solid ground floors and basement elements

In solid ground floors and basement elements the ground temperature is related to the air temperature, but has to be adjusted for the presence of the building above (which makes the ground warmer) and also for the time lag between changes in the air temperature and ground temperature.

A reasonable estimate of monthly mean temperatures can be obtained using the following procedure[1]:

1. Calculate the average of the twelve monthly mean air temperatures, θ_m to get the mean annual air temperature, θ_{an}.

2. For each month calculate the average of the annual and monthly temperature: $(\theta_m + \theta_{an}/2)$.

   For example, if the annual mean temperature is 12.0°C and the mean temperature for June is 14°C the average monthly temperature is 13°C.

3. Offset all the values by one month, so, for example the June value becomes the July value. These are the final ground temperature values, θ_g, that are used in the calculation.

   This allows for the time lag between ground and air temperatures.

Table 2 shows the results for Eskdalemuir in Scotland. If you anticipate carrying out calculations regularly it would be worth setting up a spreadsheet to calculate the values.

Table 2: Calculating ground temperatures for Eskdalemuir

Month	Air temperature °C (θ_m)	$(\theta_m + \theta_{an})/2$	Ground temperature θ_g
January	1.8	4.4	4.8
February	1.8	4.4	4.4
March	3.5	5.3	4.4
April	5.7	6.4	5.3
May	8.7	7.9	6.4
June	11.7	9.4	7.9
July	13.2	10.1	9.4
August	12.9	10.0	10.1
September	10.7	8.9	10.0
October	8.1	7.6	8.9
November	4.1	5.6	7.6
December	2.5	4.8	5.6
Mean, θ_{an}	7.06		

The external relative humidity is taken as 100% for all months.

3.2 Suspended floors

For suspended ground floors the external environmental conditions are those on the underside of the floor deck. The subfloor temperature will be somewhere between the internal and external temperatures, while the vapour pressure will be that of outside air.

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[1]BS 5250 Annex D.3.2.2 states that for more accurate figures three-dimensional numerical analysis should be used.

BS EN ISO 13370 Annex E contains algorithms for determining the subfloor temperature, θ_{sf}, but for a reasonable approximation for houses and buildings of a similar size, with $0.0015\,\text{m}^2$ of subfloor ventilators per metre of perimeter, we can use the following equation:

$$\theta_{sf} = \theta_e + X_r\left(\theta_i - \theta_e\right)$$

Where:

θ_e is the external air temperature in °C.

θ_i is the internal air temperature in °C.

X_r is a factor dependent on the thermal resistance of the floor structure, R_f and the building type. It is derived from one of two equations.

For terraced houses:

$$X_r = 0.0079{R_f}^2 - 0.1126R_f + 0.683$$

For detached houses:

$$X_r = 0.0073{R_f}^2 - 0.1057R_f + 0.508$$

For example, a terraced house with a floor deck resistance of $3.5\,\text{m}^2\text{K/W}$ would have a value of X_r of 0.39:

$$X_r = \left(0.0079 \times 3.5^2\right) - \left(0.1126 \times 3.5\right) + 0.683$$

You can either calculate R_f by adding up the resistances in the floor deck, or take it from the upper and lower limits of thermal resistance shown when you let your mouse hover of the U-value result in the status bar. (There is no point including thermal bridging in the calculation for condensation risk analysis, so these two values should be the same.)

Table 3 shows the results for such a house in Eskdalemuir, Scotland. If you anticipate carrying out calculations regularly it would be worth setting up a spreadsheet to calculate the values.

The subfloor relative humidity will be the same as the external relative humidity.

Table 3: Calculating subfloor temperature for Eskdalemuir

Month	External air (θ_e)	Internal (θ_i)	Temperature Sub-floor (θ_{sf})
January	1.8	20	8.8
February	1.8	20	8.8
March	3.5	20	9.9
April	5.7	20	11.2
May	8.7	20	13.1
June	11.7	20	14.9
July	13.2	20	15.8
August	12.9	20	15.6
September	10.7	20	14.3
October	8.1	20	12.7
November	4.1	20	10.2
December	2.5	20	9.3

3.3   Setting up the environmental conditions in JPA Designer

JPA Designer enables us to create and save specific sets of environmental conditions using the environmental pre-sets feature. To use the correct temperatures we need to create two new pre-sets , one for the external conditions and one for the internal conditions.

> ### ✎ Why do we need an internal conditions pre-set?
> It might seem strange that we have to create an pre-set for the internal conditions, given that we usually only have to select the humidity class. However, this is one of the side effects of having below-ground external conditions which are different from the standard external conditions for the location. The internal conditions still have to be derived from the normal external air, but not from the below-ground conditions. As a result, we need a pre-set for the internal conditions that is representative of the location, but independent of the external conditions.

The simplest way to set up the environmental conditions is to start with the internal conditions pre-set, basing it on the results of the external air condition, then defining the sub-floor conditions pre-set.

- For an internal conditions pre-set:

  1. Create the U-value calculation and open the **Environmental Conditions** dialogue.
  2. Select the most appropriate external location, then select the humidity class and the internal temperature.
  3. Note down the internal conditions shown in the data table. You can now use these to create an internal conditions pre-set as described in subsection 3.4.
     If you leave the internal conditions set as they are, you can create a new pre-set and have the values visible as you create the pre-set.

- For a solid ground floor or basement element external pre-set, follow the instructions in subsection 3.4, using the temperatures you have calculated from subsection 3.1 and set the relative humidity to 100% for all months.

- For a suspended ground floor pre-set, follow the instructions in subsection 3.4, using the temperatures you have calculated from subsection 3.2 and the relative humidity for the location.

3.4 Creating a new environmental conditions pre-set

To create a new environmental conditions pre-set:

1. In a U-value calculation open the **Environmental Conditions** dialogue.

2. Click **Manage environmental pre-sets**.

3. In the **Manage environmental pre-sets** dialogue click **New**.

4. In the **Edit pre-set** dialogue (Figure 1):

   - Set the **Condition** to *External*.
   - Enter a **Name** for the pre-set.
     Including ground *or* sub-floor *in the name makes it easier to recognise later.*
   - Set the **Region** to *UK* or *Ireland*.
   - Set the **Climate** to *Maritime*.
   - In the table enter the temperature and relative humidity values.

5. Close the **Edit pre-set** dialogue, then close the **Manage environmental pre-sets** dialogue.

4 Setting up the U-value calculation

Table 4: Setting element types

Construction	JPA Designer element	Special requirements
Solid ground floor	Floor other than ground floor	Include 2 metre layer of soil
Suspended ground floor	Floor other than ground floor	Ignore bridging in deck
Basement floor	Floor other than ground floor	Include 2 metre layer of soil
Basement wall	Wall	Include 2 metre layer of soil

The following sub-sections describe the procedures for carrying out condensation risk analysis for all ground floor and basement elements. Table 4 summarises the conditions for each element type in **JPA Designer**.
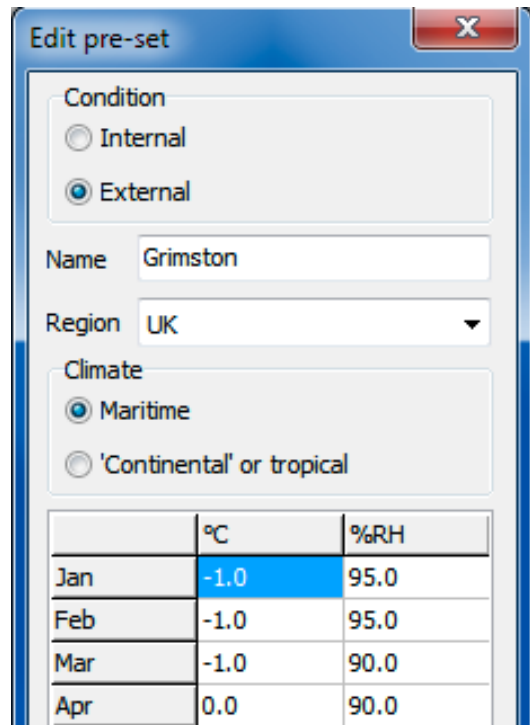
Figure 1: The upper part of the **Edit pre-set** dialogue

4.1 Solid ground floor and basement floor

Rather than using the usual *solid ground floor* or *basement floor* element type, both ground floor and basement floor condensation risk calculations use the *floor other than ground floor* element type. The ground is the represented by a 2 m thick layer of soil: typical thermal conductivity and vapour resistivity values for different soil types are shown in Table 5. The calculation should include all the other layers in the construction.

Table 5: Typical performance values for soil

Soil type	Thermal conductivity (W/mK)	Vapour resistivity MNs/gm
Clay or silt	1.5	250
Sand or gravel	2.0	250
Sedimentary rock	2.3	1250
Granite	2.8	50,000
Hard limestone	1.7	1000

Follow the sequence below to carry out condensation risk analysis in JPA Designer. The sequence presumes you have already saved environmental pre-sets for internal and external environmental conditions as described in subsection 3.1:

1. Start a new U-value calculation and in the **Construction** dialogue set the **Element type** to *Floor other than ground floor*.

	Layer	Thickness (mm)	Thermal Conductivity (W/mK)	Thermal Resistance (m²K/W)	Vapour Resistivity (MNs/gm)	Vapour Resistance (MNs/g)
1	Inside surface resistance	-	-	0.170	-	-
2	Concrete screed	65.0	1.149	0.057	500.00	32.50
3	Medium density (2000 kg/m3) concrete	150.0	1.350	0.112	500.00	75.00
4	Polyethylene, 500 gauge (0.12 mm) (BS 5250)	-	-	-	-	250.00
5	Polyisocyanurate	100.0	0.030	3.300	450.00	45.00
6	Clay or silt	2000.0	1.499	1.334	250.00	500.00
7	Outside surface resistance	-	-	0.040	-	-

Figure 2: Layers in a typical solid ground floor calculation

2. Enter the layers for the floor construction.

3. Enter a 2 m thick layer of soil between the last layer of the floor and the external surface resistance. Use values from Table 5 (for other types of rock you can inspect the entries in the products database to find suitable values).

   The layer should be entered as 2000 mm *thick. In Figure 2 the soil layer is marked in red.*

4. In the **Environmental Conditions** dialogue:

   - Set the **Building location** to the external pre-set you created earlier.
   - Set the **Source of internal conditions** to *Use design data*, then select the internal pre-set you created earlier.
     As you are using a pre-set there is no need to select a humidity class or set the temperature.

5. Click **OK**.

6. View results using the **Dew point graph** and **ISO 13788 results table**.

4.2 Suspended ground floor

Rather than using the usual *suspended ground floor* element type, suspended ground floor condensation risk calculations use the *floor other than ground floor* element type. The calculation should only include the floor deck itself. As the analysis only considers one point through the main part of the construction there is no need to include bridging in any layers; so beams of beam and block floors may be omitted. Figure 3 shows a typical construction: note the absence of bridging, shown by the red square.

Follow the sequence below to carry out condensation risk analysis in JPA Designer. The sequence presumes you have already saved environmental pre-sets for internal and external environmental conditions as described in subsection 3.2:

	Condensation - suspended ground floor | | | Floor	Thickness (mm)	Thermal Conductivity (W/mK)	Thermal Resistance (m²K/W)	Vapour Resistivity (MNs/gm)	Vapour Resistance (MNs/g)	Pitch (º)	Bridge Details	
1	Inside surface resistance	-	-	0.170	-	-			
2	Particleboard (600 mg/m³)	19.0	0.140	0.136	250.00	4.75			
3	Polyethylene, 500 gauge (0.12 mm) (BS 5250)	-	-	-	-	250.00			
4	Polyisocyanurate	75.0	0.030	2.500	450.00	33.75			
5	Concrete screed	15.0	1.149	0.014	500.00	7.50			
6	Celcon Standard	100.0	0.150	0.667	50.00	5.00			
7	Outside surface resistance	-	-	0.040	-	-			

Figure 3: Typical suspended floor deck for condensation risk analysis

1. Start a new U-value calculation and in the **Construction** dialogue set the **Element type** to *Floor other than ground floor*.

2. Enter the layers for the floor construction.

3. In the **Environmental Conditions** dialogue:

   - Set the **Building location** to the external pre-set you created earlier.
   - Set the **Source of internal conditions** to *Use design data*, then select the internal pre-set you created earlier.

     As you are using a pre-set there is no need to select a humidity class or set the temperature.*

4. Click **OK**.

5. View results using the **Dew point graph** and **ISO 13788 results table**.

4.3   Basement wall

Condensation risk calculations for basement walls should use the *wall* element type. The ground is the represented by a 2 m thick layer of soil: typical thermal conductivity and vapour resistivity values for different soil types are shown in Table 5. The calculation should include all the other layers in the construction.

Follow the sequence below to carry out condensation risk analysis in JPA Designer. The sequence presumes you have already saved environmental pre-sets for internal and external environmental conditions as described in subsection 3.1:

1. Start a new U-value calculation and in the **Construction** dialogue set the **Element type** to *Wall*.

2. Enter the layers for the wall construction.

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3. Enter a 2 m thick layer of soil between the last layer of the wall and the external surface resistance. Use values from Table 5 (for other types of rock you can inspect the entries in the products database to find suitable values).

   The layer should be entered as 2000 mm *thick.*

4. In the **Environmental Conditions** dialogue:

   - Set the **Building location** to the external pre-set you created earlier.
   - Set the **Source of internal conditions** to *Use design data*, then select the internal pre-set you created earlier.

     As you are using a pre-set there is no need to select a humidity class or set the temperature.*

5. Click **OK**.

6. View results using the **Dew point graph** and **ISO 13788 results table**.

5   Completing the calculation

Once you have entered the construction and the environmental data you can examine the calculation results. First open the **Dewpoint graph**. You will probably need to extend the window downwards, as the 2m of soil in the construction will take up much of the graph in the initial view.

The best way to inspect results is the **ISO 13788 Condensation Table** which allow you to inspect each interface in turn. You can select this from the **View** menu.

PDFs of calculations can be created using the **PDF** button on the toolbar, or from the **File** menu by selecting **Create PDF**. Make sure the **condensation risk** box on the status bar is ticked.

> ✎ **What parts of the report should I include?**
>
> When you print or create a PDF of the calculation results you can choose which pages to include in the report, including the ISO 1378 table and the summer condensation graph. We strongly recommend you do *not* include the U-value report, as the U-value obtained from a calculation designed for condensation risk analysis will not be correct for analysing heat transfer.

6   Further information

Information about JPA Designer may be found at http://www.techlit.co.uk.

Technical support by email only to support@techlit.co.uk.

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