Darren Coppins explains how computers can be used to model thermal junctions and diagnose damp

Testing the water

The use of thermal imaging can provide valuable information for the diagnosis of condensation, which can often be associated with poor thermal bridging or, where older buildings are concerned, the omission of insulation.

Insulating the existing fabric of a building, either internally or externally, can worsen the situation if material is not correctly applied. For instance, insulation can potentially cause interstitial condensation in fabric junctions, resulting in the undetected degradation of the fabric or structural elements in a wall.

Computer simulation

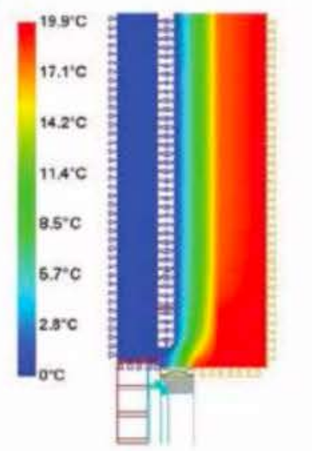
Junctions can be digitally simulated by using data from thermal imaging and knowledge of the building's original structure, which in turn enables diagnosis of the initial problem and evaluation of potential solutions. This evaluation is undertaken with finite element mesh analysis, a method more commonly used to evaluate bridging for Standard Assessment Procedure calculations, and this usually results in significant passive measures that reduce fabric heat loss.

Today, a number of different software tools are available for such analysis. The junction or thermal bridge detail that requires study is modelled in two or three dimensions, depending on the heat flow and the junction's complexity. The software then generates a mesh, splitting the detail into many individual cells. Equations relating to the flow of heat from cell to cell can then be solved in a process that is repeated iteratively by the computer until a thermally balanced solution is found.

“ Junctions can be digitally simulated from thermal imaging data and the building's structure

Figure 1

Temperature gradient through fabric



The result provides temperature information across the junction, showing where the heat flows through the fabric (see Figure 1). From this information, condensation risk can be calculated for a range of internal humidity conditions, including poorly ventilated spaces and areas with high moisture gain such as bathrooms and kitchens.

The junction can also be dynamically simulated by changing internal and external conditions each side of the fabric. This permits the thermal mass of the fabric and the associated delay in materials' reaction to temperature change to be considered.

Such calculations can be used to evaluate how elements with a high thermal mass react when externally insulating a masonry wall. In a steady-state snapshot, the problem may seem to have been eliminated, yet in an occasional or very intermittent heating scenario, a material of high thermal mass that is in contact with the internal environment can still result in condensation because the material is slow to warm up compared to the surrounding air. Such scenarios are few and far between, but they highlight the need to consider usage patterns.

Application example

An existing social housing development was suffering from internal condensation and mould growth on the junction between an external first floor and wall. Thermal imaging identified that the problem was caused by low surface temperature resulting in surface condensation, and not by fabric degradation causing water ingress.

The construction was modelled using PsiTHERM software and existing conditions replicated. In total, five separate junction types were identified and, through the computational analysis, it was proved that condensation would occur in all of them during the winter. This accorded with conditions seen on site.

Several insulation options were examined, including cavity fill and external applications. The software demonstrated that external insulation of 30mm with a thermal conductivity of λ0.025W/mK would be required to resolve the risk of condensation fully due to the nature of the thermal bridge.

With combined use of thermal imaging and computational modelling of heat flow through building junctions and thermal bridges, a robust solution to an ongoing problem was found and replicated in the model before being implemented.

Challenges

The quality of the calculation results depends on the quality of the input to the model. At the time of publication, there is no accreditation course available for the calculation of fabric heat transfer using this method, other than the training that software houses provide in the use of their own tools. Self-accreditation can be undertaken, however, whereby an individual can prove their own competence by matching a set of sample calculations provided by the BRE.

U-value, thermal bridge and surface condensation calculations and analysis are generally covered by BS EN ISO 8990, BS EN ISO 12567: 1 and 2 and BRE publications BR443, BR497 and IP1/06.

Darren Coppins is an independent building physics engineer working for Baily Garner
darren.coppins@bailygarner.co.uk