Don't be afraid to ask

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Continuing his series on the connections between building design, failure and occupants? lifestyle, Michael Parrett considers how poor design contributes to damp problems

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The main elements that produce a bad design are cost, material selection, and the design and consultationprocess. Take the massive increase in public housing after the Second World War, particularly up to the 1960s, when the same designs for concrete-panelled buildings were used nationwide. At the time, these were deemed to be a very cost-effective way to build mass housing quickly and expediently. Low costs were a big driver in their rapid roll-out.

Unfortunately, the heat loss from these buildings often bordered on disastrous and significantly affected the living conditions of tenants. They were very difficult to heat and most required additional insulation to try to arrest condensation, mould and damp.

As with many projects, when costs start to exceed budget, solutions are needed: one is to alter the design. The result is that an original, robust design and the eventual as-built construction may be different; for example, where waterproofing of below-groundstructures in high-water table areas is compromised, along with the external attenuation required to adequately drain the site.

Material selection

As innovation progresses in construction, material selection is becoming increasingly complex, especially as architects and constructors often need to demonstrate the useof environmentally friendly solutions, new technologies, materials and approaches, they need a solid challenge to ensure the design actually works in practice, especially how it will be used when occupied. A multidisciplinary approach is needed, which commonlyincludes structural engineers through to sustainability experts, but it is importante.g. sedum roofs and materials from sustainable sources. But who knows if today?s materials are going to be tomorrow?s champion or disaster?

Look at previous material use. Many inter-war cottages have solid walls covered with a hard, cementitious render and pebbledash, used as an external barrier system. They mayhave looked aesthetically pleasing, but hard Portland cements may crack and allow moisture penetration. Using these cements is now known to be incorrect, especially on older and historic buildings that need to breathe.

Design issues - case study 1

It is rare to find an architect who takes full responsibility for drainage design. Adesign and build brief is usually given to a small contractor. This often causes anissue if a design is faulty and questions are asked about who is accountable.

I know of an example of poor drainage design on a college building with a shallow-pitched, lightweight metal roof to save cost, surrounded by a very high brick parapet wall. There was a linear box gutter on each side of the roof for displaced rainwater, with six pipes and hopper connections.

During heavy rainfall, the gutters filled with water, which rose above the edge of the roof slopes at the eaves and was pushed up underneath the corrugated roofing and into the building. Initially, the problems were thought to be because of detritus and physical obstructions to the gutters and outlets through the parapet walls and collecting hoppers.

The design of the building made it extremely difficult for maintenance staff to access the roof regularly without erecting expensive scaffolding (the building was put up before the introduction of the Construction Design Management Regulations, and such adesign would not be tolerated today). However, even once all the obstructions were cleared and protective netting was installed to help prevent further blockages, the gutters continued to fill with water.

We found a problem when we assessed the building holistically; we looked at the roof area, pitch, parapet wall height, gulley/outlet/hopper size, rainwater downpipe diameter,rainwater bounce off the inside of the parapet walls and the official rainfall intensity for the region (detailed in BS EN12056 Part 3:2000). When the whole design was subjected to a proper drainage calculation, it was found to be hydraulically short, i.e. unable todisperse water fast enough during heavy or prolonged periods of rainfall.

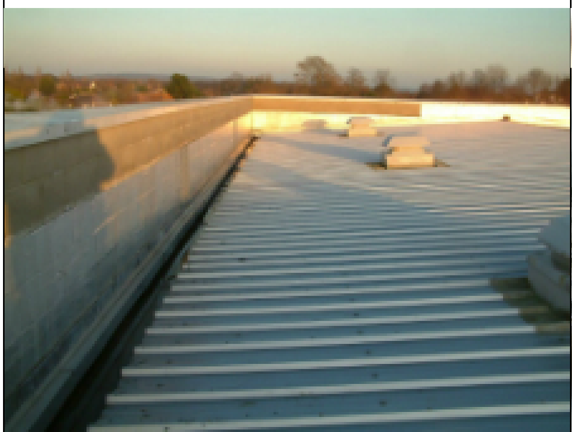

Figure 1: Roof drainage. Shallow corrugated metal, dual-pitched roof with high perimeter parapet walls. Little allowance for water falls towards the hoppers and downpipes

Figure 2: Outlets through parapet walls gutter too narrow and the depth of the gutter to the eaves too shallow. Roof suffered from algae growth, leaf litter and airborne detritus. Together with chartered regional rainfall averages, the drainage system was deemed hydraulically short.

mg class="image_centre" src="/images/parrett_2_1.jpg" alt="damp3" /> **Figures 3 (above) and 4 (right): Melted and distorted plastic soil vent pipes. Pipes can increase in length by around 3?4mm at 20?C. Even pipes resistant to high temperatures can only withstand 100?C for up to a minute. Expansion will also result in stressing pipe joints for interconnecting waste services.**	mg class="float_centre" src="/images/parrett_4_1.jpg" alt="damp4" />

The design and consultation process

Historically, clients have been good at defining basic requirements, but were maybe not terribly well informed about the design and consultation process. The result is that the process has been driven by the designer and constructor to realise the client?s vision.

But with architects often pushing the boundaries of schemes to incorporate new technologies, materials and approaches, they need a solid challenge to ensure the design actually works in practice, especially how it will be used when occupied. A multidisciplinary approach is needed, which commonly includes structural engineers through to sustainability experts, but it is important to include a wider range of of disciplines, especially building failure experts who will pose awkward questions along the lines of ?What if ??? Otherwise, who will ask about preventing rainwater penetration through joints, the effect of the sun?s heat on a lead roof or whether gutters can handle heavy rainfall?

Do not forget how a design impinges on the landscape, and vice versa; take into account factors such as rainfall intensity, wind, whether the building is in an elevated position or lowland valley, drainage and flooding risk. The elements can have a huge impact on the required robustness of a building?s design and should be considered early in the process.

Design issues causing damp

Blocks of maisonettes, which aimed to maximise space while minimising cost, were common in the 1960s and 1970s. They were often designed with a kitchen and living room at ground level, stairs leading to a large bedroom at the rear, and a bathroom and bedroom at the front. This was usually cantilevered out over a communal walkway and probably gave an extra 3?4m 2 of living space.

But that push to create extra space created real problems. The projection normally consisted of part of the bedroom floor slab exposed over the walkway and two side walls, which were partly external because they extended from the building line. Thefront wall would, in some cases, also include a full-height window frame or possibly low-level timber or replacement PVC infilled panels. Add a top floor with its uninsulated flat roof (Building Regulations were not introduced until 1965) and it is a very thermally inefficient design.

These maisonettes are prone to condensation; the surface temperatures during winter of those external areas are often permanently below the dew point temperature of the internal air (the temperature at which the water vapour contained in a given volume ofair reaches saturation and condenses to form a condensate; this is charted in BS 5250). The condensation is usually can identify hot and cold spots while environmental monitoring will measure the temperature and moisture content of internal and external air, expressed as relative humidity. This allows the psychrometric calculation of the dewpoint temperature. Thermistors can also be used to monitor fluctuations in the surface temperature of the external envelope and determine its thermal efficiency. Heat transmittance calculations can determine U-values and caused by normal daily activities (such as cooking, washing and bathing) but it can become more severe with overcrowding and lack of adequate heating and ventilation.

Flat roofs and their abutment with parapet walls and around drainage outlets are probably most vulnerable to water penetration. The projecting rooms have enormous problems of cold bridging and resultant condensation, including the phenomenon known asinterstitial condensation. This is where the dew point temperature is reached within the building mass so condensate drips out of the structure, and is often misdiagnosed as rainwater penetration. Thermal bridging has been an issue in the design of different types of buildings over the past 100 years or so.

Most of the resultant damp and mould issues caused by some maisonette designs would usually relate to the thermal inefficiency of the building envelope, but this could be exacerbated by defective or inappropriate materials.

Design issues - case study 2

We investigated a large new-build block of flats where residents made repeated complaints of damp patches and mould, and we discovered a complex matrix of grey plastic soil vent pipes running throughout the building. Many of these were distorted, and the dampness and mould was on the ducting and adjoining walls. We also found that hot watercylinders were overheating because of defective thermostats. These cylinders were fitted with expansion pipes routed into the soil vent pipes, so scalding hot water, caused by the defective thermostats, was running into the soil vent pipes and melting them in sections between floors.

A leading manufacturer of these pipes told us they could withstand 100?C hot water for only one minute. These discharges were happening regularly over time and many occupierswere completely unaware that their cylinders had problems.

Solving this mechanical and electrical design issue caused huge problems. It required major opening-up works to replace the damaged sections of pipes,which were on different floors and of varying configurations. An alternative was to install separate copper overflow pipes routed down through the building, but this would have required even more major opening-up works.

It was decided the best solution was to replace all the hot water cylinders with a type that did not require expansion pipes to be connected to the soil vent pipes and which were fitted with a failsafe cut-off in case of overheating, avoiding expansion.A related issue was found where the melted soil vent pipes passed through the concrete floor slabs. This impaired compartmentalisation and increased the risk of fire spreading, which required separate notification to the local fire service.

Figure 6: Upper box-bedroom projections lacked any insulation to the flat roof above, exposed floor slab below or side cavity walls. Internal conditions worsened when fenestration was changed to PVCu double glazing, as this helped retain heat but also moisture

Figure 5: A 1960s four-storey block of maisonettes. The lower bathrooms and front bedrooms have partially exposed solid floors and ceilings neither had any original insulation.

Diagnosing problems

Measuring the fabric of the building is crucial to identifying design-related problems. Thermal-imaging cameras can identify hot and cold spots while environmental monitoring will measure the temperature and moisture content of internal and external air, expressed as relative humidity. This allows the psychrometric calculation of the dewpoint temperature. Thermistors can also be used to monitor fluctuations in the surface temperature of the external envelope and determine its thermal efficiency. Heat transmittance calculations can determine U-values and a massive leap that should not beundertaken lightly.

Before questioning use and occupation of the dwelling, eliminate any contribution to the internal dampness equation from the building design and/or any defects.

Retrofit solutions

Design-related damp problems do not end with thermally inefficient buildings. My previous article (One thing leads to another) considered design failures associated with different building periods. These range from a lack of roof undersarking in the 1920s and 1930s to solid ground-supported floors laid without damp-proof membranes until the 1960s.

These failures all increase the risk of damp, humid homes. Therefore, retrofitting energy-saving solutions without understanding the endemic design issues from different building periods merely increases this risk. It is common for designers and installers ofretrofit solutions to overlook a building?s history and inbuilt faults that increase the risk of condensation.

Many inter-war cottages had steel-framed, single-glazed windows. If PVCu or aluminium double-glazed units are installed, any moisture that used to condense on those old, thermally inefficient windows will just move to another cold area, often the juncture ofwalls and ceilings or the internal corner of two external walls.

A multidisciplinary approach

Cost and material selection (especially new technologies) will always affect abuilding?s design, but sometimes this will not be apparent until many years after itsconstruction.

So how do we reduce the risk of design problems causing damp?

The answer has to be a multidisciplinary team; the more people studying a design and asking awkward but valid questions about it, the more chance that it will work.

Perhaps there should be a major rethink on the use of professional indemnity insurance. At present, many built environment professionals are very reluctant to accept responsibility for the design aspects of building elements such as drainage, and instead abrogate that responsibility or pass it on to a commercial contractor. Would it not bebetter if built environment professionals did not have to avoid this responsibility because they perceive that the risk is too great?

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Further information

- BS 5250:2011 Code of practice for control of condensation in buildings
- BS EN 12056 Part 3:2000 Gravity drainage systems inside buildings. Roof drainage, layout and calculation
- Images ? Michael Parrett
- First in the series: One thing leads to another
- This feature is from the RICS *Property* journal (May/June)