2021-06-28

Lessons from the Classroom – assessing the work of postgraduate students to support better hygrothermal risk assessment

Joseph Little
Technological University Dublin, joseph.little@tudublin.ie

Benat Arregi
Tecnalia, benat.arregi@tecnalia.com

Christian Bludau
Fraunhofer Institute for Building Physics, christian.bludau@ibp.fraunhofer.de

Recommended Citation
Joseph Little, Benat Arregi and Christian Bludau. Lessons from the Classroom – assessing the work of postgraduate students to support better hygrothermal risk assessment. DOI: 10.14293/ICMB210087

Lessons from the Classroom – assessing the work of postgraduate students to support better hygrothermal risk assessment

Joseph Little [a], Beñat Arregi [a,b], Christian Bludau [c]

a Dublin School of Architecture, TU Dublin, Ireland
b Tecnalia, Basque Research and Technology Alliance (BRTA), Spain
c Hygrothermal Department, Fraunhofer Institute for Building Physics (IBP), Germany

Abstract

The widespread adoption of transient simulation modelling tools by building design professionals to support hygrothermal risk assessment of building design specifications is a crucial component in a multi-pronged drive to reduce moisture risk in buildings. Structured upskilling is essential. Much can be learnt about the ways practitioners use such tools by reviewing the work of professional postgraduate student groups. Such review could inform the creation of a user protocol. Peer-review under the responsibility of the organizing committee of the ICMB21.

Keywords: building design professionals; transient simulation; hygrothermal risk assessment; high-quality modelling

Nomenclature

MCQ	Multiple choice questionnaire	CPD	Continuous Professional Development
ECTS	European Credit Transfer & Accumulation Scheme	AVCL	Air and vapour control layer

1. Introduction

1.1. Background

It is estimated that approximately 75-80% of building failures relate to moisture [1]. In the last decade the drive to build and renovate to increasingly onerous standards, a similar increase in well-publicised failures and risk-averse clientele, have led to greater awareness amongst building design professionals that hygrothermal risks of many building specifications need to be assessed and mitigated through use of transient simulation modelling tools validated to EN 15026:2007 [2], such as WUFI® Pro. Advocacy bodies such as the UKCMB see the adoption of these relatively complex modelling tools by non-scientists as a crucial component in a new and multi-pronged drive to reduce moisture risk in buildings [1].

The success of this adoption will be dependent on the extent to which practitioners upskill in appropriate knowledge, skills and behaviour. Presuming they have adequate knowledge of building technology, practitioners must acquire appropriate knowledge of building science, standards and the selected modelling tool. They must learn to apply appropriate technical skills in creating high-quality models, assessing the outputs and communicating these in a sober, clear and replicable manner. Lastly, they must cultivate behaviour - in this case a willingness to apply scientific rigor and a healthy mistrust of models they create.

Risk assessment is not about identifying precise values, instead it is the purposeful navigation of a landscape of probability and consequence. George Box's aphorism that *'all models are wrong; some are useful'* is well known [3]. The authors contend that a skilled assessor can create useful, even accurate models, despite varying precision (see Figure 1a): this is an important distinction. While there will always be natural variability to manage, knowledge uncertainty can be reduced by, for example, improved models, greater availability of building material datasets and provision of hourly climate files by the Met Office, increasing precision over time. Without doubt the robustness and replicability of high-quality models and assessments will be greatly assisted by the creation and adoption of a protocol governing usage and interpretation. This has been a notable absence since EN 15026 was first published.

2. Lessons from the classroom

2.1. Masters-level upskilling

Technological University Dublin provides a 5-ECTS, masters-level module on hygrothermal risk assessment (featuring *WUFI® Pro* and *BuildDesk U*) in Stage 1 of *MSc in Building Performance (Energy Efficiency in Design)*. The module is taught over six weeks. During each of the first four weeks, students view three hours of lectures, and complete a formative multiple-choice questionnaire (MCQ) exploring knowledge or a modelling task that is then discussed in a live webinar. Two timed MCQ exams are also held in this period. The final two weeks are focused on a mini-project based on a detailed brief. At the end of the fifth week a half-day workshop allows significant feedback on a selection of draft submissions. A week later, students submit final, revised projects. The lecturing team believe the approach taken in this module sets students on a solid path to acquire the necessary knowledge, skills and behaviour.

 DOI: 10.14293/ICMB210087

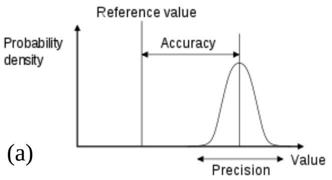
2.2. User techniques

Inter alia, students are taught a range of user protocols to support high quality modelling and assessment. These include:

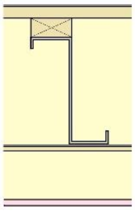
a) Careful selection of parameters: In any situation countless numbers of *variables* will be present but only those that influence the risk under consideration should be considered *parameters* eligible for selection. For instance, a client may regard roof colour as having aesthetic value only, but a skilled practitioner will know that short-wave radiation absorptivity is strongly influenced by colour and can greatly influence hygrothermal performance so should be explored parametrically.

b) Bracketing: This is a technique used in parametric assessment where two or more characteristics of a real building material are considered to have a particular bearing on risk but their values are poorly understood. As an example, when risk assessing historic external solid masonry walls of unknown characteristics, the authors recommend that the assessor use a bracketing approach in the selection of the bricks from the WUFI® material database, focusing on Water Absorption Coefficient (A, $kg/m^2\sqrt{s}$) and Moisture Storage Function (kg/m^3). As the A-value can be derived from a simple, onsite moisture absorption test, the assessor can make a bracketed selection of alternative materials in the database, which have similar A-values but widely differing moisture storage functions, with reasonable assurance that the actual material lies between [4].

(a)



(b)



(d)

Parameters								
Rainfall construction	Membrane colour (absorptivity)	Bracketing of roof membrane	Vapour resistance of AVCL	Shading (from parapets, service	Air infitration into roof	Bracketing of insulation	Roof orientation	Roof pitch
1	3	1	3	1	4	1	1	1
1	2	1	2	1	1	2	1	1
2	2	1	2	2	2	2	2	1
2	2	1	2	1	2	1	1	1
1	3	1	1	1	3	1	2	1
2	2	1	2	1	3	1	1	1
2	2	1	1	1	5	1	1	1
2	3	1	2	1	2	1	2	1
2	3	1	1	2	2	1	2	1

Figure 1. (a) Relationship between accuracy and precision; (b) roof structure of project; (c) excerpt from table assessing student choices

2.3. Assessing student projects

In 2019-20 the brief required creation of a report to a fictitious client on the hygrothermal risks associated with the renovation of a flat roof of a commercial building in Glasgow, which features cold-formed metal purlins, quilt insulation, engineered boards and roof membrane. Thirty-seven projects were submitted. Despite the structured teaching in the module and detailed project brief there was quite a bit of variety in the students approach to parametric selection and assessment of outputs. Their choices are briefly reviewed and compared with those of Christian Bludau, a member of the Hygrothermal Department in IBP and a practitioner with specialist knowledge in risk assessment of flat roofs.

- 81% of students modelled wetting of the sheathing board during construction, but six used too low a figure and two others incorrectly modelled with a moisture source.
- Like Bludau, 27% of the class modelled three membrane colours. 70% chose two membrane colours.
- Like Bludau, 83% selected only one roof membrane. One student however selected six types of membranes.
- Three students selected two types of plasterboard despite this layer having minimal impact.
- 67% of students selected two levels of air infiltration to assess its impact varied. Like Bludau, 24% selected three or more air infiltration levels.
- Bludau selected four levels of indoor moisture load (coupling this with air infiltration). Three students selected three levels and 76% selected only two moisture loads.

The following assessment approaches of students are of interest:

- 62% of students correctly chose 18% as the critical threshold water content by mass-%. 22% of class selected 20 mass-%.
- 27% physically modelled the roof membrane. The rest, like Bludau, included it as a boundary condition with an s_d-value.
- 54% assessed that all cases were too risky. 24% considered it acceptable if a dark membrane and/or AVCL was used.

3. Conclusions

Structured upskilling is necessary to ensure that building design professionals can create and assess high-quality hygrothermal models with sufficient value and accuracy. All practitioners would be greatly aided by the creation of a user protocol. It would be instructive for those seeking to create a user protocol to review the variety of approaches that even trained users may use when carrying out hygrothermal risk assessment, as can be seen in this short paper.

References

[1] May, N., & Sanders, C. (2017). *Moisture in buildings: an integrated approach to risk assessment and guidance*. BSI, London.
[2] Anon. (2007). *BS EN 15026 Hygrothermal performance of building components and building elements — Assessment of moisture transfer by numerical simulation*
[3] Box, G., Luceño, A., & Del Carmen Paniagua-Quiñones. (2009). *Statistical Control By Monitoring and Adjustment*. Wiley, USA
[4] Arregi, B., & Little, J. (2016) "Hygrothermal Risk Evaluation for the Retrofit of a Typical Solid-walled Dwelling," *SDAR* Journal of Sustainable Design & Applied Research:* Vol. 4: Iss. 1, Article 3.