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Development of performance-based standards for external timber cladding

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Abstract

This paper reviews the background to, and development of, new British Standards for external timber cladding. The standards are being produced because timber has become a widely used external cladding material in the UK and this has highlighted that existing standards on the topic are inadequate. When fully published, the BS 8605 series will offer performance-based specifications and guidance on the main issues affecting external timber cladding. The standards involve multi-compliant performance measures; several technical conflicts had to be addressed.

Keywords: Timber; external cladding; performance-based design; technical standards; moisture; facade.

1. Background

It used to be so easy. Technical standards used to follow a prescriptive ("do this, do that") type of format that was simple to write and to use. The prescriptive approach could be restrictive, however, and was a barrier to innovation and trade. Technical standards are, therefore, moving towards being performance-based where requirements are defined in terms of measurable user need, with the means of compliance left unspecified. Although this move is to be welcomed it does make technical standards more complex; so much so that that some are becoming unusable by parts of their audience, as well as being slower and more demanding to write. Three difficulties are particularly common.

Firstly, what happens when a technical standard spans several performance criteria some of which conflict? The fire safety of a facade, for example, might have to be integrated with criteria such as durability. Fire safety often

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requires that cavity ventilation is blocked but this can increase fungal decay risk. Life safety obviously over-rides other criteria but does this mean that second level issues have to be ignored?

Secondly, how can the performance approach be applied to durability? Performance requirements need to be stated as a limit state. Much research has been undertaken on the initial properties of structural components but, until recently, there has been little work on the equally important topic of degradation of component properties. This is especially the case with timber degradation. Performance models should be capable of evaluating the risk of degradation in performance capacity over time, with a coefficient of variation related to that capacity [1]. But existing data on timber durability cannot yet be generalized as a parametric model. Thelandersson *et al*. [2] give a state-of-the-art review.

Thirdly, what happens when a user need cannot be verified? Performance requirements must be verifiable – they must be readily falsifiable using established scientific or engineering principles – but some issues are untestable. The weathering characteristics of a facade, for example, are important for the building's designer and users, but are often impossible to predict from short term tests.

1.1. Growth in timber facades in the UK

These challenges have recently been highlighted in the UK. Timber-clad facades are widely used in North America and Scandinavia and in recent years have undergone a substantial revival in the UK and central Europe. Previously used mainly on low-rise housing, timber cladding is increasingly appearing as an external finish on medium-rise buildings, multiple occupancy housing and for non-domestic applications such as offices. So long as timber was only used to clad low-rise, single-occupancy dwellings on relatively sheltered sites it was simple to design and install; there were few technical risks. But the growing use of this cladding on large, complex buildings – and on exposed sites – has increased the associated risks, such as wind damage or fire spread. Timber now has to achieve equivalent performance standards to other, longer established, cladding materials. Suitable specifications and design recommendations are urgently needed for external timber cladding in the UK. But can the challenges of multi-compliance, parametric modelling and verifiability really be addressed for timber facades?

1.2. Timber as a facade material

Timber, as distinct from other cladding materials, is biogenic (derived from living organisms) and organic (carbon based with at least one C-H bond). Materials can be categorized by whether they originate, directly or indirectly, from living organisms or other sources: biogenic materials such as timber that originate directly from living organisms tend to be non-uniform, whereas transformed biogenic materials (e.g. coal, plastics) are more uniform. Organic compounds hold large amounts of energy in their chemical bonds, are thermodynamically unstable and, given the right conditions, revert to a more stable form, releasing energy during the process. Organic–biogenic materials share a further characteristic, moisture sensitivity. Timber, therefore, has three key characteristics as a facade material: non-uniformity, combustibility and moisture sensitivity [3].

None of these characteristics prevents timber being used externally – far from it. The differences between timber and other mainstream construction materials are, however, manifested through two distinct approaches to facade design. Thus, many published accounts of rainwater penetration through cladding focus on leakage through the joints between impermeable sheet materials but ignore moisture flow through the cladding itself; this is an important issue for timber-clad facades. Similarly, discussions of facade corrosion usually omit the effect of organic acids.

These differences between timber and more traditional cladding materials mean some existing performance criteria for facades are not directly transferable to timber. Facades are constantly exposed to fluctuating moisture conditions: the relationship between wood and water tends to dominate the design. Combustibility and non-uniformity have to be managed while not increasing moisture related deterioration. This is usually done through the use of what can be termed timber rainscreen cladding.

1.3. Timber rainscreen cladding

Screened walls – where the external cladding is separated from the wall structure using a cavity – are common in the UK. The cavity provides a capillarity break between the cladding and substrate and promotes evaporative drying of the wall. In a modern insulated wall, the cavity is sealed from air inside the building but may be connected to the outside. Ventilation of the cavity to the outside removes water vapour diffusing from inside a building and increases the drying rate of cladding that has been wetted by wind driven rain. The term rainscreen cladding is usually used to describe screened walls with well-ventilated cavities or cavities screened by cladding with frequent open joints to the outside. Rainscreen cladding is the most common approach with timber facades. Although the idea of a screen for the rain is long established, its scientific basis was only investigated from the 1940s onwards [4,5]. A large literature has since accumulated, albeit much of it is only relevant to specific materials, construction types or test conditions.

1.4. Moisture conditions in timber rainscreens

Davies *et al* [6] have undertaken one of the largest data-logged exposure trials of timber rainscreen cladding to date. The three year trial spanned a wet and a dry site in Scotland. Figure 1 gives an excerpt from their results.

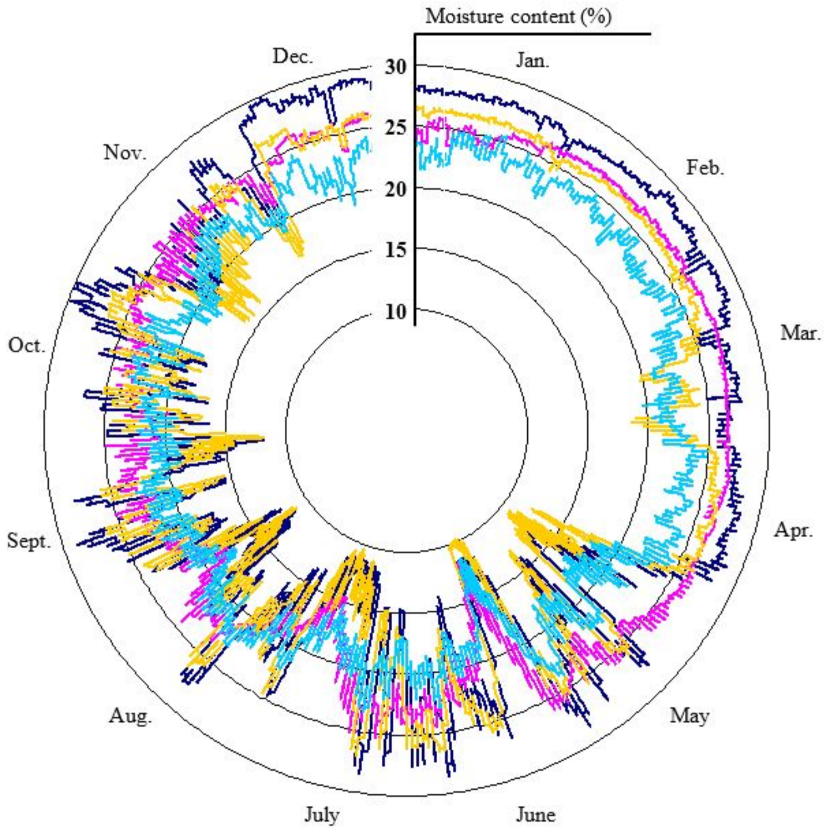

Figure 1. Moisture contents in four timber-clad test panels in Scotland during 2007

Three moisture content cycles can be observed in Figure 1. Firstly, there is an annual cycle, in which moisture contents are high between December and April but fluctuate widely during the other months. Secondly, there is a storm cycle between May and November in which moisture content fluctuation is driven by precipitation events. Thirdly, there is a diurnal cycle with the daily moisture content range being narrowest during the winter.

The trial found that the mean moisture content in the heartwood of timber in an external cladding assembly is around 16% during dry weather, whereas during rain storms it can range up to a modal value near the fibre saturation point (FSP) for the timber species concerned. The mode is affected by ventilation, surface coatings, timber permeability and other factors. The minimum moisture content is around 10% irrespective of species and appears to be consistent with the Langmuir type sorption characteristic of many porous materials [7].

These findings call into question some published statements regarding moisture conditions in external timber cladding. Typical estimates are of a maximum moisture content of 22% and a mean of 16%, irrespective of precipitation conditions. There are two likely explanations for the discrepancy between these estimates and Figure 1. Firstly, some estimates are simply calculated as equilibrium moisture contents and ignore wetting by rainwater. Secondly, even where measurements are taken they tend to be small in number and are unrepresentative of the full range of sites, timber species and in-service conditions.

2. Methods

As interest in timber facades grew and additional research became available, the UK timber cladding industry – as represented by the Timber Decking and Cladding Association (www.timbercladding.org) and others – started to discuss the need for national technical standards. Accordingly, in 2012 the British Standards Institution established the B543/0/02 drafting panel to develop a series of standards on external timber cladding. The drafting panel was chaired by a representative of Edinburgh Napier University's Centre for Sustainable Construction who also prepared first draft of each standard. Other panel members helped revise these drafts prior to them being issued for public consultation, final editing and publication. As originally proposed, the BS 8605 series on external timber cladding was to consist of two documents [8,9]. BS 8605-1 was conceived as a specification for use by designers and manufacturers, with BS 8605-2 being a code of practice for designers and contractors. The result was slightly different.

3. Results

External cladding made of boards and wood-based panels come within the scope of harmonized European Standards EN 14915 or EN 13986, respectively [10,11]. Where a product characteristic is covered by one of these standards, it has to have a Declaration of Performance and be CE marked. Only some performance characteristics are included. Although these requirements have applied in most of Europe for over a decade, they only became mandatory in the UK in 2013. Prior to this, UK timber cladding suppliers ignored EN 14915 and EN 13986 because it was felt that they were inaccurate and incomplete. However, since 2013, UK suppliers of timber cladding have had to adopt to these norms. This change occurred as the BS 8605 series was being prepared and had a large impact upon the drafts.

Because EN 14915 and EN 13986 are harmonized specifications, a National Standards Body such as BSI cannot issue conflicting specifications for a product even in cases where the European norms have errors or omit important performance criteria. Therefore, BS 8605-1 could no longer be a specification and instead had to be restructured as a method of specifying. This type of British standard "*gives characteristics of a material, product, process or system so that a customer can select the values needed before agreement with a supplier*"[12] p.29. The published version of BS 8605-1 thus addresses designers instead of manufacturers and has a two part structure. If a performance characteristic is covered by CE marking, the standard simply gives recommendations on how to use that European performance specification. Performance characteristics not covered by CE marking are given as a specification.

3.1. Robustness in service conditions

Traditionally in the UK, structural engineers have not been involved in the design of external timber cladding assemblies, except on some tall buildings or when checking the work of others following the building's completion. This can lead to problems when robustness is not properly addressed at the design stage. Consequently, BS 8605-2 gives simplified engineering design guidance that is suitable for most circumstances and highlights the conditions where a full structural analysis is recommended; this threshold is set at a peak wind suction of 2.5 kN/m^2. The simplified guidance is based on the Eurocodes [13,15] and follows similar methods in other British standards [15,16]. Most of the guidance concerns the attachment of support battens to the wall. Support battens are not covered by harmonized standards, although some European strength grading criteria do apply.

3.2. Hygrothermal performance

EN 14915 and EN 13986 give performance characteristics for water vapour permeability and thermal conductivity of external timber cladding. Water vapour resistance factors for three wood densities are given and a test method is provided for manufacturers who wish to declare a better value. Thermal conductivity values for wood are also given. By suggesting, without cautionary guidance, that water vapour permeability and thermal conductivity are applicable to external timber cladding, these standards are misleading facade designers into thinking that the cavity and cladding can always be included in hygrothermal calculations of building envelope performance, whereas they should in practice be excluded if the ventilation conditions are such that the cavity is equivalent to outside air. Parts of the UK are exposed to high levels of wind driven rain and so BS 8605-2 recommends that timber rainscreen cladding should be well ventilated on exposed sites. In accordance with ISO 6946 [17] the minimum cavity gap for a well ventilated cavity is set at 1500 mm^2/m^2 of horizontal surface area; in which case the cavity conditions are similar to outside air.

3.3. Reaction to fire

EN 14915 gives Classification Without Further Testing (CWFT) criteria enabling the reaction to fire performance of some types of external timber cladding assembly to be classified on the basis of published test results. Unfortunately, the existing CWFT criteria are inapplicable to many timber rainscreen cladding assemblies in the UK because the cavity has to be well ventilated (see 3.2) and the rear face of the cavity is made of combustible materials. This is causing problems because some UK timber cladding manufacturers are claiming a reaction to fire performance classification that cannot be evidenced. The BS 8605 series gives guidance on the reaction to fire classifications that are appropriate for external timber cladding in the UK.

3.4. Fire resistance

If a facade fire enters a cavity it can spread five to ten times its original height irrespective of the combustibility of cavity linings [18]. Many building regulations for facades require that cavities have barriers in specific locations to help control this fire spread. This requirement is in conflict with the need for cavity ventilation (see 3.2). Standardized tests for the fire resistance of cavity barriers on ventilated facades are poorly developed, particularly where the cladding or cavity linings are combustible. This creates much confusion; building regulators sometimes impose their own arbitrary criteria, while cavity barrier manufacturers are able to make unverifiable performance claims. Research into this topic is ongoing, but from the limited data that are available it appears that some types of intumescent cavity barrier can help resolve the conflict. Alternative solutions employ a fire engineering approach involving sprinklers and other measures [19]. For the purposes of the BS 8605 series, a fire engineering approach was deemed too complex and so intumescent cavity barriers were used. Construction details were developed that integrate these barriers into separating wall and floor junctions that ensure ventilation and acoustic separation. It is recognized that this guidance might have to be revised as further data become available.

3.5. Durability and service life

The influence of water upon durability or other time dependant processes is not fully understood. Consequently, there is no up to date standard that addresses all factors affecting the selection of durable timber for specific moisture exposure situations such as external cladding. EN 460 [20] and BS 8417 [21] give general guidance on the suitability of timber, of a particular natural durability class, for application in a specific moisture exposure situations although both of these norms have their limitations. Although EN 460 contains useful guidance, it is now quite dated. A major revision is of this standard is underway as part of a new approach to wood performance classification being developed by European Standards technical committee CEN/TC 038 but this has not yet been published. BS 8417 is a code of practice for the preservative treatment of wood. It gives verifiable criteria enabling preservative treatment to be selected. However, the selection of non-preservative treated timber, particularly for components such as external cladding involves a wider range of factors, some of which are currently unverifiable. Consequently, the BS 8605 series has had to give relatively conservative guidance on timber selection. It is hoped that this can be improved upon in the near future as new data become available.

4. Conclusions

When fully published in autumn 2015, the BS 8605 series will be the first relatively complete set of specifications and recommendations for external timber cladding:

- BS 8605-1 gives methods of specifying all relevant material and product characteristics
- BS 8605-2 will give recommendations enabling most timber clad facades to be designed and constructed

Strategies for resolving design conflicts are presented and the BS 8605 series highlights the circumstances where specialist engineering input is advisable. Some issues could not be fully resolved. These include the service life of external timber cladding and ways of addressing unverifiable characteristics such as weathering. It is hoped that these can be addressed in the future as new research becomes available.

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References

[1] ISO. General principles on the design of structures for durability. ISO 13823. International Organisation for Standards, Geneva; 2008.
[2] Thelandersson, S., Isaksson, T., Suttie, S., Frühwald, E., Toratti, T., Grüll, G., Viitanen, H. and Jermer, J. Service life of wood in outdoor above ground applications: Engineering design guideline background document. Report TVBK-3061. Division of Structural Engineering. Lund: 2011.
[3] Davies, I., Fairfield, C., Stupart, A. and Wood, J. External timber cladding: design and performance. The Structural Engineer, 12, 2012, 46-53.
[4] Birkeland, O. Curtain walls. Handbook 11B. Oslo: Norwegian Building Research Institute; 1962
[5] Garden, G.K. Rain penetration and its control. Canadian Building Digest 40. Ottawa: National Research Council of Canada; 1963
[6] Davies, I., Fairfield, C., Stupart, A. and Wilson. P. Moisture conditions in timber cladding: field trial data. In: Proc. ICE, Construction Materials. 165(5), 263–279.
[7] Langmuir, I. The constitution and fundamental properties of solids and liquids. Part 1. Solids. J. Am. Chem. Soc. 38, 11. 1916; 2221-2295.
[8] BSI. External timber cladding, Part 1: method of specifying. BS 8605-1. London: BSI; 2014
[9] BSI. External timber cladding, Part 2: code of practice for design and installation. BS 8605-2, London: BSI. (In prep.)
[10] CEN. Solid wood panelling and cladding – Characteristics, evaluation of conformity and marking. EN 14915. Brussels: CEN; 2014.
[11] CEN. Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking. EN 13986. Brussels: CEN; 2004
[12] BSI A standard for standards – Principles of standardization. BS 0. London, BSI; 2011
[13] CEN. Eurocode 1: Actions on structures – Part 1.4: General actions – wind actions. EN 1991-1-4. Brussels, CEN; 2010.
[14] CEN. Eurocode 5: Design of timber structures. Part 1-1: General, Common rules and rules for buildings. EN 1995-1-1. Brussels, CEN; 2008.
[15] BSI. Slating and tiling for pitched roofs and vertical cladding. Code of practice. BS 5534. London, BSI; 2014.
[16] BSI. Structural design of low-rise buildings. Code of practice for masonry walls for housing. BS 8103-2. London, BSI; 2013.
[17] CEN. Building components and building elements – Thermal resistance and thermal tranmittance – Calculation method. EN ISO 6946. Brussels, CEN; 2007.
[18] Colwell, S. and Martin, B. Fire performance of external thermal insulation for walls of multi-storey buildings, BRE Report 135. Watford, UK: BRE Press; 2003.
[19] Bart B., Kotthoff, I. and Weiderkehr, R. Aussenwände – Konstruktion und Bekleidungen. [External construction – cladding. In German] Zurich: Lignum – Dokumentation Brandschutz; 2009.
[20] CEN. Durability of wood and wood-based products — Natural durability of solid wood — Guide to the durability requirements for wood to be used in hazard classes. EN 460 Brussels, CEN; 1994.
[21] BSI. Preservation of wood. Code of practice. BS 8417. London, BSI; 2014.