STA Advice Note 14

Robustness of CLT Structures

STRUCTURAL TIMBER ASSOCIATION
Building solutions in timber

No. 14 - Part 1, March 2017

Part 1 - Key principles for moisture durability

The purpose of advice note 14

To provide good practice guidance for the design, concept detailing and installation of panelised Cross Laminated Timber (CLT) building structures.

Scope of application

Heated buildings such as dwellings, hotels, school buildings and offices. For panelised construction, not volumetric construction, which may require additional detailing and design criteria.

Advice note 14

This series of advice notes by the STA provides good practice design principles to reduce installation mistakes and includes guidance on installation to deliver durable, robust CLT buildings.

The advice note is set out in five parts for ease of reference and application by the building team involved in a project.

- Part 1 - Key principles for moisture durability
- Part 2 - Key principles for CLT wall to foundation interfaces
- Part 3 - Key principles for good practice detailing for the external envelope of CLT
- Part 4 - Construction process best practice
- Part 5 - CLT Structural design and manufacturing quality assurance

This series of documents should be read in conjunction with other design guidance, in particular:

- CLT manufacturer's handbooks
- Building Regulations
- Third Party Warranty Standards e.g. LABC and Premier.

Acknowledgements

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Endorsed by LABC Warranty and Premier Guarantee.

Kind thanks to our sponsors

Introduction

CLT is manufactured using quality controlled softwood material which has little natural defence against decay caused by sustained high levels of moisture; which for design purposes is 20% moisture content (or above) for a reasonable period of time. Correctly designed, constructed and maintained CLT structures will not be subjected to high moisture, but incorrect installation or poor maintenance of the building envelope may create conditions for moisture to become trapped. It is essential that the design team, installation team and follow on trades understand the building materials being adopted.

The five key design principles addressed in this advice note are:

- CLT is not to be positioned on the cold side of an external envelope, that is the CLT is on the warm side of the external wall insulation
- Detailed and built to create dry environment conditions and avoid in-service water traps
- The walls are breathable with a cavity to allow internal moisture to diffuse
- Roofs are warm roofs with adequate falls for water run off
- Construction process is considered in the design to avoid on site moisture traps.

The key installation principles are:

- CLT interfaces with the substructure are to be correctly detailed as indicated in Part 2 of Advice Note 14
- Storage, installation and protection of the CLT should be undertaken by installers who understand and have knowledge of timber as a construction material (STA quality assured members)
- Supervision of the works to reduce poor workmanship and interference by follow on trades is part of the durability risk mitigation process; for which the STA have provided a check list (part 4) for STA members to complete for site works
- Localised surface protection of exposed timber end grain that can be subjected to wetting during construction is to be provided together with robust detailing of junctions and membranes. Vulnerable areas are noted in the advice note parts 2 to 3
- STA members CLT technical manual to be followed.

Advice note 14 - reference guide to key points

Project life process	Key points to consider	Advice Note 14 series reference
Design	Understand moisture durability issues	**Part 1** Key principles of CLT moisture durability
	Details to avoid moisture build up from ground level Robust weather protection Construction process details to avoid temporary water build up External envelope or exposed timbers to be maintainable	**Part 2** Key principles for CLT wall to foundation interfaces **Part 3** Key principles for good practice detailing for the external envelope of CLT
	Building physics resolved with internal vapour being able to diffuse out of the structure - walls and roof- without condensation collecting on the timber elements	**Part 1** Key principles of CLT moisture durability
Procurement	Correct material specification	**Part 5** CLT structural design and quality assurance
Construction	Materials are to be stored so as not to absorb moisture from prolonged weather or saturation from storage in puddles Inappropriate construction details that trap moisture Protection of exposed timber elements	**Part 4** Construction process best practice
	Processes to avoid vulnerable elements or areas or elements that may be subjected to unintentional but foreseeable moisture build up	**Part 2** Key principles for CLT wall to foundation interfaces **Part 3** Key principles for good practice detailing for the external envelope of CLT **Part 4** Construction process best practice

Table 1 Key points to consider for CLT moisture durability

As in any building, good designs can be ruined by poor workmanship and unintentional design changes due to the ignorance of the constructor making changes.

This advice note is to ensure that the designer considers the issues and provides the information that the constructor is to use and not deviate from. In addition the advice note is for the constructor to be aware of the duties and protection needed during the construction process. In summary this advice note series is for practicable details which do not invite error or change.

Design life and maintenance

The use of CLT panels in structures is an approach to use the benefits of sustainable timber products in an intelligent way to produce robust structures from which durability is expected to exist for the design life of the structure.

No building is immune from requiring normal maintenance and upkeep. This advice note series is for structures to achieve a design life that accepts occasional and standard maintenance works to some cladding, glazing and other internal and external finishes.

Applications of CLT

CLT manufacturer's European technical assessments provide approval for CLT panels in Eurocode classifications of Service Class 1 and 2.

Design Service Class 1 conditions are for timbers that are within the building envelope which are not exposed to external humidity and temperatures, but generally heated to keep the timber in a dry condition at 12% or below.

Service Class 2 applications are those where timber can be in contact with external humidity and temperatures, but not exposed to direct wetting, such as parapet walls protected from direct rain exposure by waterproofing membranes and claddings.

The insulation to external walls and at roof level means that the CLT is on the warm face and under these conditions the CLT structure complies with Service Class 1 in accordance with Eurocode 5 (BS EN 1995-1-1:2004 clause 2.3.1.3). Internal panels and floors are in a heated building in Service Class 1. The use of CLT structures exposed to Service Class 2 is not covered by this advice note. Service Class 2 applications require bespoke review and consideration of durability.

Key principles for build-up of external envelope walls

- CLT on warm side of insulation
- Insulation continuous on the external envelope of the structure
- Breathable insulation protected by a breather membrane
- Cavity vented to allow moisture to disperse and any water seeping through the external cladding to drain out away from the breather membrane / insulation face.

See **Figs 1-4** for typical CLT wall constructions. See Advice Note 14, Part 3 for further information, advice and good practice detailing for CLT walls and roofs.

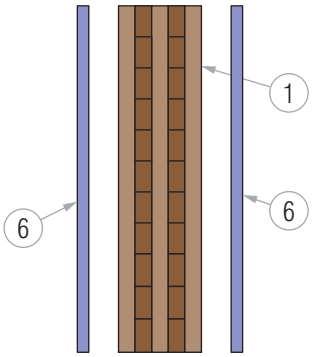

Fig 1.1 Internal walls (heated buildings) ***Service Class 1 for both sides of the CLT***

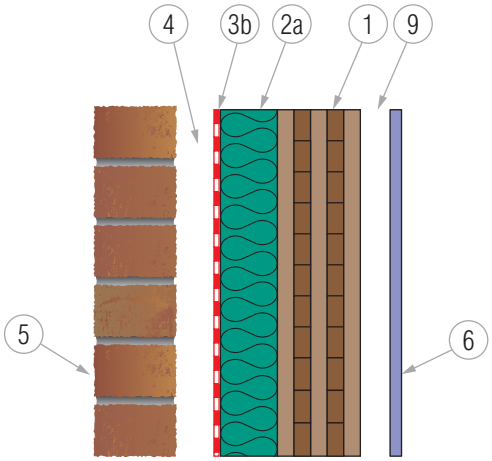

Fig 1.2 External walls (warm wall construction - breathable insulation) ***Service Class 1 for both sides of the CLT***

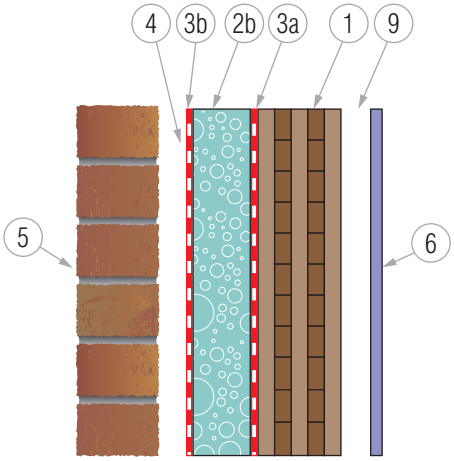

Fig 1.3 External walls (warm wall construction - rigid foam)

Key to Figs 1.1 - 1.3

1. CLT
2a. Breathable thermal insulation (see page 5 **Part 3 - Key Design Principle 6**)
2b. Tight-jointed rigid foam insulation
3a. Breather membrane to CLT face; subject to condensation and site wetting risk analysis
3b. Breather membrane to insulation face; subject to insulation type and jointing techniques (always required on breathable insulation)
4. Drained and vented cavity
5. Cladding spaced off the insulation
6. Optional drylining and battened service zone
9. Hydrothermal checks will typically demonstrate that a vapour control layer is not required

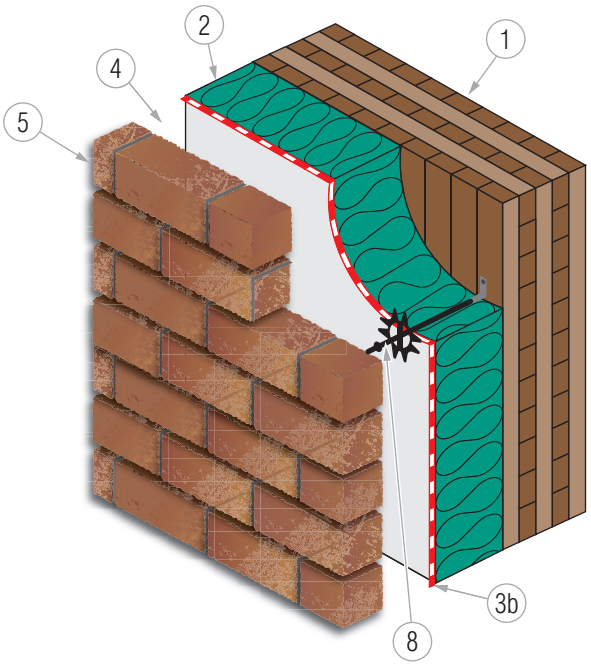

Fig 1.4 CLT external wall (with breathable insulation materials)

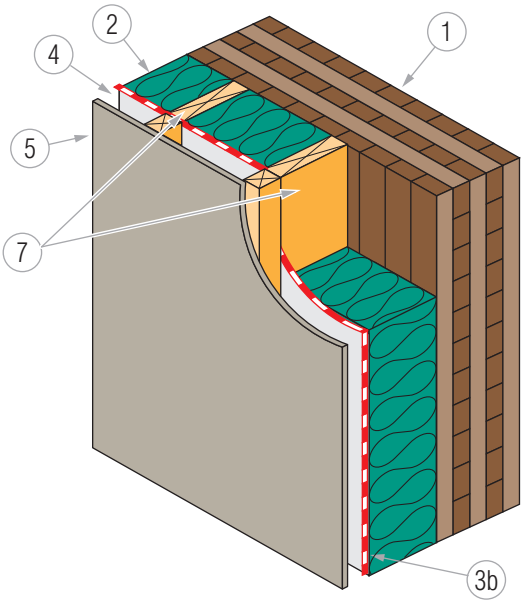

Fig 1.5 CLT external wall (supported cladding with secondary batten system)

Key to Figs 1.4 and 1.5

1. CLT
2a. Breathable thermal insulation (see page 5 **Part 3 - Key Design Principle**
2b. Tight-jointed rigid foam insulation
3a. Breather membrane to CLT face; subject to condensation and site wetting risk analysis
3b. Breather membrane to insulation face; subject to insulation type and jointing techniques (always required on breathable insulation)
4. Drained and vented cavity
5. Cladding spaced off the insulation
7. Treated timber cladding battens
8. Wall ties

NOTES for Figure 1.5

Cladding battens are fixed with screws directly to the CLT. Where Insulation is not sufficiently rigid to support the cladding battens a secondary batten layer is included within the insulation to support the cladding. A layered system of battens (with insulation in corresponding layers) is provided. Where it is necessary to minimise cold bridging, battens can be fixed at right angles to one another. Screws to individual batten layers are to be designed by an engineer.

Thermal bridging of battens to be included in a building physics assessment.

Battens in Service Class 2 conditions require preservative treatment.

General note on cavity ventilation (no. 4 on key)

Vented or ventilated cavities according to the design requirements and technical standards (Scotland) and Building Regulations (England and Wales). Also reference to BS 5250:2011+A1:2016

Design process for durability

Key principles for durability

1.	Ensure there is an appropriate external cladding with a drained and vented cavity that provides protection from rain penetration to the inner wall build up. Note a ventilated cavity with through air is recommended where there is a high rain index so that rain penetration is dried more efficiently than a single vent line cavity. The required installation of cavity barriers should not compromise these principles.
2.	A specific Vapour Control Layer (VCL) is unlikely to be needed in a CLT structure, however , where installed it should be on the warm side of the thermal insulation.
3.	The CLT shall be detailed so that it is on the warm side of the insulation. Condensation risk analysis calculations are to be carried out to verify that no condensation will occur at the insulation/CLT interface in accordance with BS 5250.
4.	Thermal bridging is avoided by the insulation layer on the outer face but some battens and fixings may occur for which a separate assessment will be required.
5.	Gaps in insulation layers are not acceptable as this may cause a condensation risk.
6.	Insulation shall be located on the outside face of the CLT and should be of a breathable type. Foil faced products may not be breathable and require special attention to check the vapour resistivity of the interface between CLT and insulation within the interstitial condensation check. In addition a further breather membrane may be required between the CLT and insulation to avoid condensation issues at the board joints. The joints of rigid insulation built up in layers should be staggered and taped.
7.	Adhesively bonded CLT panels are in accordance with their ETA approval air tight. The Joints and junctions are typically made airtight with junction detailing or with airtightness tape installed on the outer or inner face of the CLT at junctions as appropriate to the design strategy of the building envelope. An option is to adopt a combined airtightness and breather membrane for the envelope may also be considered.
8.	In the CLT construction process the moisture content of the CLT panel shall be below 20%.
9.	During delivery and storage the panels are to be appropriately protected against weather and ground water.
10.	During erection of panels high moisture content areas should be prevented at all junctions and connection points. Water should not become trapped nor moisture allowed to build up at any panel junction.

STA advice on the requirement for preservative treatment to CLT and protection against moisture

Preservative treatment of the CLT panels may be required if the following conditions apply:

1. The CLT panel is located on the cold side of the external envelope
2. The good practice detailing in Parts 2&3 of this Advice Note are not followed or justification is not provided for omission of preservative treatment
3. Where the STA member does not follow and execute the CLT check list - refer to advice note Part 4
4. Where weather protection to the CLT frame is not in accordance with advice note Part 4
5. Use of wax based end sealant to vulnerable areas as noted in parts 2 and 3 are not followed.

Compliance with BS 8417:2011+A1:2014 Preservation of wood

BS 8417:2011 is the British Standard that presents recommendations and guidance for the preservative treatment of wood to provide protection against bio deterioration in end-use situations. It gives recommendations for determining the need for treatment.

The use of the CLT in this advice note is for products largely in use class 1 (UC1) situations (Interior, covered conditions in accordance with **Table 1** of **BS 8417:2011** and **Table 1** of **BS EN 335:2013**) and are not normally treated.

Requirements for the treatment of timber, where consideration is given to the likelihood and consequences of failure from bio-deterioration, are defined in **clause 4.3** of **BS 8417: 2011:Table 2 - Service factors**. Where there is negligible risk of failure preservative treatment is considered unnecessary. Where risk of failure is low it is optional to provide preservative treatment.

In consideration of Table 2 of BS 8417:

1. CLT manufacturers typically state an intended service life of 50 years in their ETA certification whereas British Standards typically refer to 60 years design life - the indicative 50 years intended service life can be taken as equivalent of 60 years design life

2. Whitewood /redwood softwoods typically used in the manufacture of the CLT components contain sapwood as well as heartwood and are therefore considered to be 'not durable' (Durability class 5 to BS EN 350-2: 1994). The principles presented here are such that the CLT is to remain dry and consequently there is negligible design risk of decay or insect attack, for external walls, the insulation, a breather membrane and a drained and vented cavity are present on the outer side of the CLT

3. CLT in this Advice Note is typically considered to be in Service class 1 condition to EN1995-1- 1-2004. The CLT located on the warm side of the insulation will not be service class 2. By adopting good weather protection and allowing the timber to breathe as presented in Part 3 the consequence of decay risk is low as in internal timbers of a heated building and all cases the CLT is considered to be in Use Class 1 to British Standard BS EN 335:2013

4 . CLT is massive in terms of area of wood and therefore should a breach in the waterproofing occur, regardless of how remote this is, then any bio degradation of the CLT will be local in area and is unlikely to lead to structural failure of the wall or slab element

5. A continuous presence of moisture is required over time before significant damage is likely to occur to CLT panels. Normal repairs and maintenance in properties will address breaches of moisture ingress and, provided the timber is allowed to dry and that the water source is stopped, significant structural failure should not occur

6. During construction it is recognised that some areas of CLT might be exposed to standing water for short periods. The use of a moisture repellent coating will assist in reducing moisture uptake in the CLT. However, the in-service design should always be such to allow for any moisture that has been taken up by the CLT during construction to breathe and dry out.

For the applications and approach presented in this advice note the preservative treatment of CLT is not considered necessary. The design detailing presented in this advice note maintains the product in the dry environment of use class 1 to BS 8417 and Service Class 1 to EN 1995-1-1.

Summary for robust CLT design and construction durability against decay

Key principles for moisture durability

1.	Timber products will decay if moisture is present for prolonged periods; therefore good design details and construction methods as given in this advice note are essential to deliver buildings with appropriate design life.
2.	The decay threshold of timber requires substantial moisture in excess of the service class one conditions recommended for CLT structures; if the design includes for service class conditions outside of this Advice Note then a case by case basis assessment is required.
3.	If the project includes details that fall outside of this Advice Note appropriate preservative treatment may be required.
4.	Information on the material handling and protection is to be provided to the principal contractor team on site - refer to the STA member's technical manual.
5.	The CLT installer shall complete the STA product construction check list at key stages of the build (see Part 4) and submit to the principal contractor. The record should be retained on site for review by building inspectors, if required.

Requirements for interstitial condensation checks

The risk of interstitial condensation for external wall build-ups shall be assessed: A condensation risk analysis should be carried out to determine the likely risk of interstitial condensation and whether or not a VCL or other additional measures are required to BS 5250. The effect of water vapour concentrating at joints between insulation boards should be fully assessed.

Key principles for interstitial condensation

1.	Condensation risk analysis to be carried out in accordance with BS 5250:2011 Code of practice for condensation control in buildings (5)
2.	Minimum vented external wall cavities are required (refer to Part 3 - Key principles for good practice detailing for the external envelope of CLT).
3.	CLT roofs should be designed as warm roof structures with all insulation and waterproof membranes located above the CLT (refer to Part 3 - Key principles for good practice detailing for the external envelope of CLT).

References

1. **British Standard EN 1995-1-1:2004 - Eurocode 5:Design of timber structures**
   Part 1-1: General - Common rules and rules for buildings
2. **British Standard BS 8417:2011 + A1:2014**
   Preservation of wood: Code of practice
3. **British Standard BS EN 335:2013**
   Durability of wood and wood based products. Use classes: definitions, application to solid wood and wood-based products
4. **British Standard BS EN 350-2**
   Durability of wood and wood-based products. Natural durability of solid wood - Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe
5. **British Standard BS5250:2011**
   Code of practice for condensation control in buildings
6. **British Standard BS4016:1997**
   Specification for flexible building membranes (breather type)
7. **Trada Wood Information Sheet 4-28**
   Durability by design

Steering Group

Sincere thanks for the time and contribution given to this project by members of the CLT steering group.

Greg Cooper, B&K Structures
David Crawford, CCG OSM
Kay Hartmann, KLH UK
Robin Lancashire - TRADA
Guy Lewis, STA technical consultant
Gareth Mason, Stora Enso
Martin Milner, Milner Associates