Red Stag Project Guide

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Project Guide V1.0
August 2022

RED STAG®
WOOD SOLUTIONS

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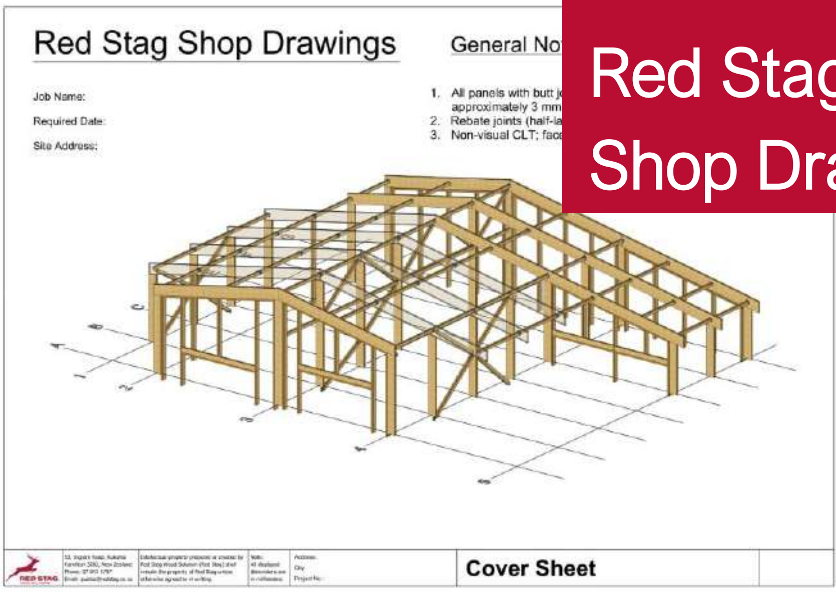
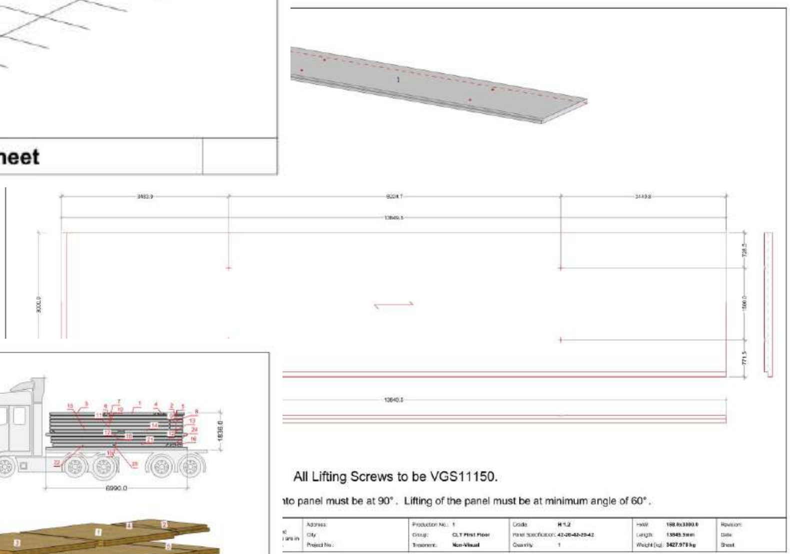
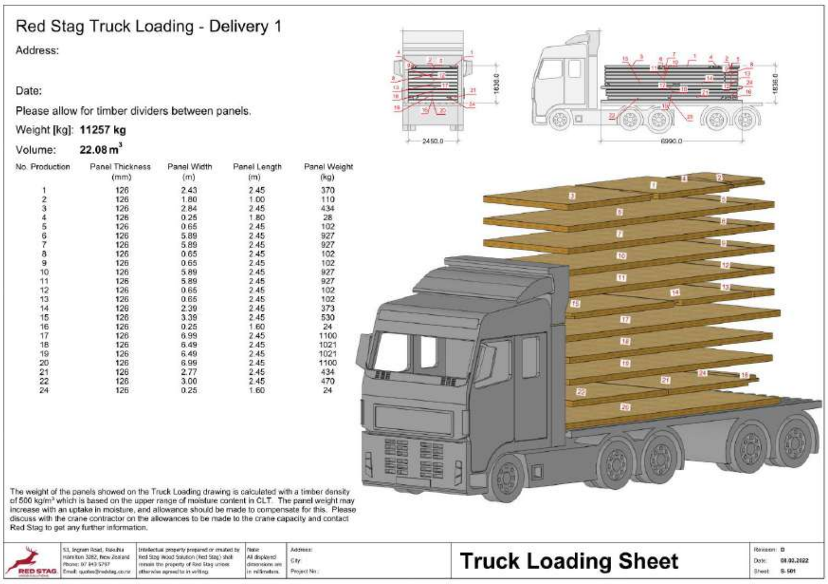
Section 1

Red Stag Shop Drawing Guide







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1. EWP Shop Drawing Overview

Red Stag Wood Solutions Limited (Red Stag) Engineered Wood Products (EWP) are manufactured to support the development of the most advanced mass timber building systems in New Zealand, making them more widely available, more efficiently produced, compliant to New Zealand standards (including treatment), more cost-effective and of higher quality.

Red Stag EWP (including Cross Laminated Timber (CLT) and Glue Laminated Timber (GLT)) are manufactured from New Zealand renewable Forest Stewardship Council ® (FSC® Licence Code: FSC-C172039)[i] certified forestry. Red Stag has constructed the first phase of New Zealand's largest and most advanced CLT plant. The scale facility can manufacture panels up to 16.5 x 4.5 x 0.42 m (Length × Width × Depth)[ii] (refer to *Figure 1*).

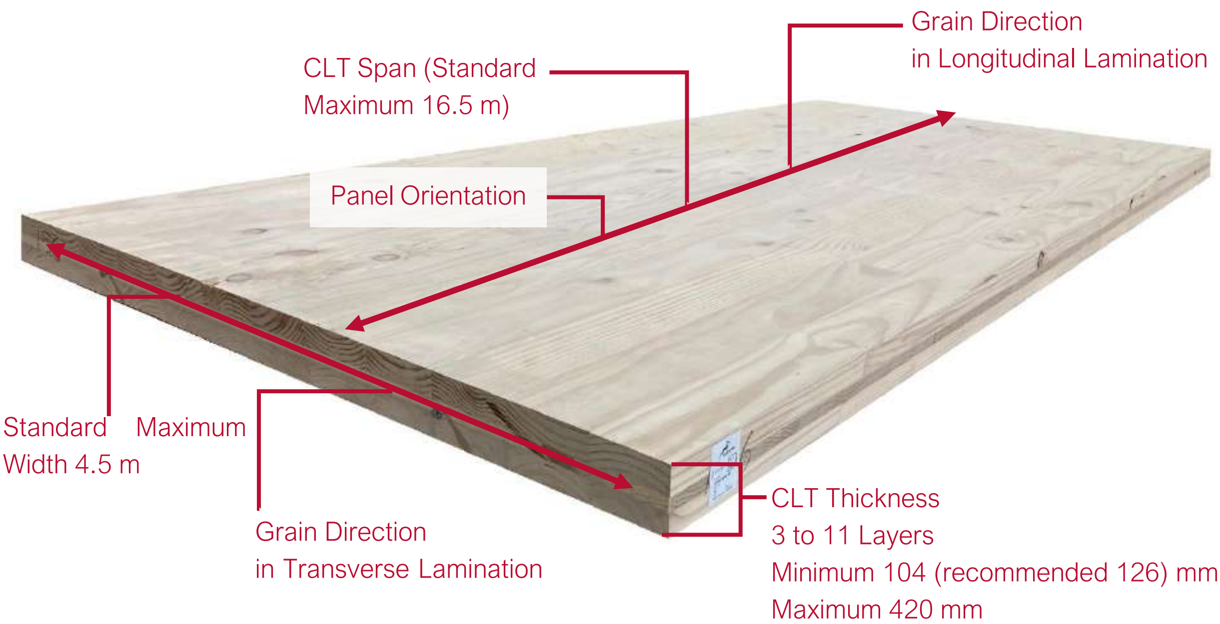

Figure 1: Red Stag CLT panel.

The Red Stag Shop Drawing Guide has been designed to aid the shop drawing process between clients, architects, engineers, and other consultants with Red Stag. This document outlines the shop drawing process from commencement to completion ready for manufacture.

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[i] Clients requiring FSC® certified product must follow strict protocols to be compliant with the FSC® auditing process. FSC® requirements must be defined to Red Stag before the quotation stage to ensure that the documentation process is compliant.
[ii] Slightly wider and longer panels may be available upon request. Please contact Red Stag if special oversizing is required.

Red Stag shop drawings provide a detailed framework for projects, including the general arrangement of EWP elements, fully dimensioned elements, element properties, element transitions and joints, dimensioned openings/penetrations, element surface requirements (grade), treatment, lifting points, and other applicable details, etc (Refer to *Figure* 7 to *Figure 13* from *Section 1*.7 of the Red Stag Shop Drawing Guide).

2. Shop Drawing Process

Red Stag EWP elements are typically machined via precision, large format timber Computer Numerically Controlled (CNC) equipment, providing efficient, and accurate processing (refer to *Figure 2*). The large scale five-axis CNC allows for complex, advanced designs, and associated Building Information Modelling (BIM) to be seamlessly converted from concepts on paper/screen into reality. To ensure the required manufacturing accuracy, the process requires an extremely detailed and accurate digital model, capturing every project element to the millimetre. Once the model is confirmed and the shop drawings are signed off, Red Stag nests elements into billets (raw panels), master beams (larger format beams) or associated timber systems based on their specification, grade, treatment, grain direction and project sequence (Refer to *Figure 3*). The shop drawing process and associated pricing estimates and quotations are based on a maximum of two iterations as illustrated in *Figure 4*. Further iterations are possible but will come at additional cost if the client misses or adds requirements (refer to Red Stag's service term sheet for hourly rates on shop drawing resources).

Figure 2: Precision large scale timber CNC processing equipment.

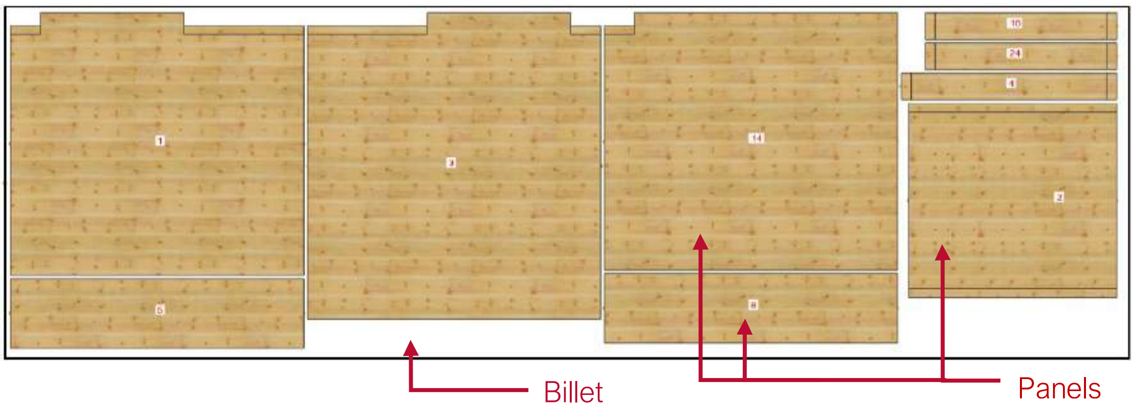


Figure 3: Red Stag CLT billet with nested panels.

1. Client to provide a complete set of project drawings with a signed copy of the completed Red Stag Client Project File Submission Confirmation document.

2. Red Stag to review the drawings and submit Requests For Information (RFI) as required to support the shop drawing process.

3. Red Stag create the first iteration (V1) of the digital model/shop drawings, with the proposed element sequence.

4. Client Project Team review V1 of the shop drawings and associated model and detail any required amendments in conjunction with the targeted installation sequence.

5. Red Stag integrate the required changes into the model and issue revision two (V2) of the digital model/shop drawings.

6. Client Project Team to review and approve V2 of the digital model/shop drawings by completing and signing the Red Stag Shop Drawing Approval Letter.

7. Red Stag create and issue (V2a) with a proposed truck loading and panel lifting sequence based on the Client proposed sequence advised in Step 4, and associated transportation and loading restrictions.

8. Client Project Team to confirm the truck loading and panel lifting methods (V2a) with fixing requirements and sign off on the Red Stag Shop Drawing Lifting and Truck Loading Acceptance Form.

9. Red Stag nest panels into billets and create a manufacturing schedule (no manufacturing can commence until this and all prior steps are completed in full for the entire project).

10. Red Stag can commence manufacturing at its discretion and process as sequentially as possible in line with or ahead of the delivery schedule.

CLT panels delivered to site or prepared for ex-works delivery with the client selected fixings and lifting devices (optional).

Figure 4: Red Stag shop drawing process.

3. Requirements

To commence the shop drawing process, Red Stag requires a complete, detailed, and accurate final set of consented drawings (electronic in suitable CAD formats), and a complete digital model incorporating all architectural and engineering details (i.e., IFC model). The drawings must be millimetre perfect, free of collisions and include explicit detail for all items that Red Stag is expected to include in its shop drawings and EWP element processing. All supplied drawings must be free on conflicts and contradictions between drawings (e.g., architectural and engineering drawings must be aligned and not conflict). Any omissions or design changes to the issued set of drawings for Red Stag to complete the shop drawings from will incur additional charges on an hourly basis over and above of the shop drawing fee (additional charges will be invoiced at the latest published hourly rates for each Red Stag design team member). Changes or omissions will also adversely impact the timeline and extend the schedule. The shop drawing process and pricing is based on a maximum of two review iterations. If additional iterations are required because of omissions or errors by Red Stag, no additional shop drawing charges will apply. If additional reviews are required because of omissions, errors or changes by the Client, Red Stag will invoice for the additional time at its defined hourly rates. Additional reviews may also adversely impact the project programme. It should be noted that delays in shop drawings and any other component of the project by the Client generally do not have a linear impact to time (e.g. a one week delay in shop drawings, may impact the project by several weeks).

Any changes to the design that impact the shop drawings, will not only impact the pricing of the shop drawings, but may trigger a price review for the required elements. Items impacting the price, include, but are not limited to: changes to the EWP specifications (grade, recipe, treatment, etc), EWP volume, EWP format and CNC complexity. Changes to the scope will be re-priced at the current EWP rates at the time of re-pricing.

The preferred file format(s) to be received by Red Stag in the order of priority are:

- IFC
- Revit (*.rvt), ACIS (*.sat)
- AutoCad (*.dwg)
- Drawing files in PDF

If the Client provided drawings are inaccurate and a suitable drawing package is not going to be provided, it may require Red Stag to create a new precise model, refine the existing model, reject or pause the project until a sufficiently suitable package is received. If Red Stag is required to and accepts to model other building elements to assist the shop drawing process, additional charges will apply, and it may adversely impact the project timeline.

Red Stag will manage provided drawing package file types in the following level of priority and importance:

1. IFC
2. RVT
3. Other three (3) dimensional models.
4. DWG
5. Two (2) dimensional drawings.

For the avoidance of doubt, if there are conflicts in the provided project drawing package, the IFC details will be utilised ahead of the RVT file details and so on. The Level Of Development (LOD) requirements from project BIM models should be minimum of LOD 200, but the recommended level is LOD 300 or higher wherever possible.

During the shop drawing process, if there are any changes that could affect the process, it is the responsibility of the Client project consultants to update Red Stag with explicitly highlighted changes in the model and associated drawings as soon as practically possible. Failure to explicitly illustrate changes that Red Stag needs to action will be charged at the hourly rates for the time Red Stag spends to identify and cross check differences in addition to the time to action. Changes outside the two review iterations will impact the shop drawing charges, shop drawing timeline and may impact the overall project timeline.

3.1. Architectural Drawing Package

The architectural drawing package is generally the primary basis for the shop drawings as it classifies/outlines the project with all dimensions, levels, and all project specific information. It is essential that the architectural drawing package has accurate plans, sections, and details with no conflicts with any other project consultant's provided details and drawings.

The required architectural drawing package suitable for shop drawings should consist of at least the following:

- Full architectural drawing package in. CAD (.IFC, .DWG, .DXF, etc.) and PDF formats, including dimensioned plan views, elevations, sections, and associated architectural details.

- Architectural floor type, wall type, roof type with correct Red Stag CLT panel thickness, treatment, and panel appearance (exposed face/faces indicated for visual graded panels) and panel span/load/grain directions.
- Precise dimensioned locations for all openings and penetrations (including all engineering services) from project specific gridlines in millimetres.
- Floor level separation details for set-downs with appropriate cross section details (e.g., wet areas, balconies, etc).
- Pitch for roof, stair, and deck CLT panels in degrees.
- All required rebates, connection details, penetrations, recesses with set-out dimensioned from project specific gridlines.

3.2. Engineering Drawing Package

The engineering drawing package typically consists of drawings and specifications from structural, hydraulic, HVAC, cladding, mechanical, electrical, fire and acoustic engineers, etc. A complete dimensionally accurate, comprehensive structural engineering drawing package is required to complete the shop drawings. The engineering package must include detailed dimensioned plans, elevations, and cross-sectional views. Detailed descriptions of element joints and transitions are required, including specific notes for tolerances, fixing positions, fixing types, fixing centres, etc to other building elements.

The structural and service engineer's drawings (including hydraulic, mechanical, electrical, fire, acoustic and cladding, etc) are expected to be coordinated with the architectural drawing package by the Client consultants to avoid conflicts and associated delays to the shop drawing process.

3.3. BIM Coordination

A component of the Red Stag shop drawing process includes the coordination of EWP elements between other project models. It is recommended for project design consultants to engage early with Red Stag to support in resolving potential issues associated with processing constraints and site installation details. To support, Red Stag require the shared BIM model(s) to open file access permissions.

If multiple project consultants (structural, architectural, hydraulic, fire, acoustic, cladding, etc) are involved in a project, it is responsibility of the Client's project consultants to ensure there are no conflicts within all provided consultant's drawings prior to issuing the document package(s) to Red Stag to commence the shop drawing process.

After Red Stag submit the first revision of the shop drawings, it is the responsibility of the Client's project consultant(s) to check the submitted shop drawings, cross check with the broader project team(s) and provide a comprehensive list of comments for Red Stag to address in the second and final set of the shop drawings.

Red Stag can provide a range of file types and documents to aid the shop drawing review process by the Client project consultants. Project consultants should discuss and advise Red Stag of the requested file type(s) prior to Red Stag commencing the shop drawing process. Typically, Red Stag will provide the following documents/files with each revision of the shop drawings as required (Refer to *Figure 7 to Figure 13* from *Section 1.7* of the Red Stag Shop Drawing Guide):

1. A component drawing for every element (plan, elevation, end elevation and isometric) in PDF format. Each drawing page will provide dimensions, recipe configuration, treatment, grade, and component number, etc.
2. Three dimensional (3D) model in IFC format (Red Stag can provide files in DWG, DXF, SAT, and RVT if requested).
3. Questions and comments for Client project consultants as required.

Once the finalised shop drawings are approved by the Client project consultants (refer to *Appendix A* for the required sign off form by the authorised Client representative), Red Stag will create a truck loading plan. The truck loading plan will follow the Client's targeted assembly sequence as much as practically possible; however, may vary slightly based on the following requirements (Refer to *Figure 13*):

1. Each bundle (depending on the load configuration, there may be multiple bundles per truck/trailer unit) requires a large longitudinal element (the base layer should have the grain running in the X-axis – refer to *Figure 5*) on the bottom to create the foundation for the balance of the bundle to be stacked on.
2. Bundles require the elevation (longitudinal X-axis of the load) to be stacked in a pyramid format as much as practically possible, from longest on the bottom to shortest on the top to manage the stability and reduce element overhang and associated deflection.
3. Bundles require the end elevation (longitudinal Y-axis on load) to be stacked in a pyramid format as much as practically possible, from widest on the bottom to narrowest on the top to manage the bundle stability.
4. To reduce the risk of deformation of elements, bundles require dunnage (larger

fillets) between each layer in the Z-axis (refer to

5. Figure 5).

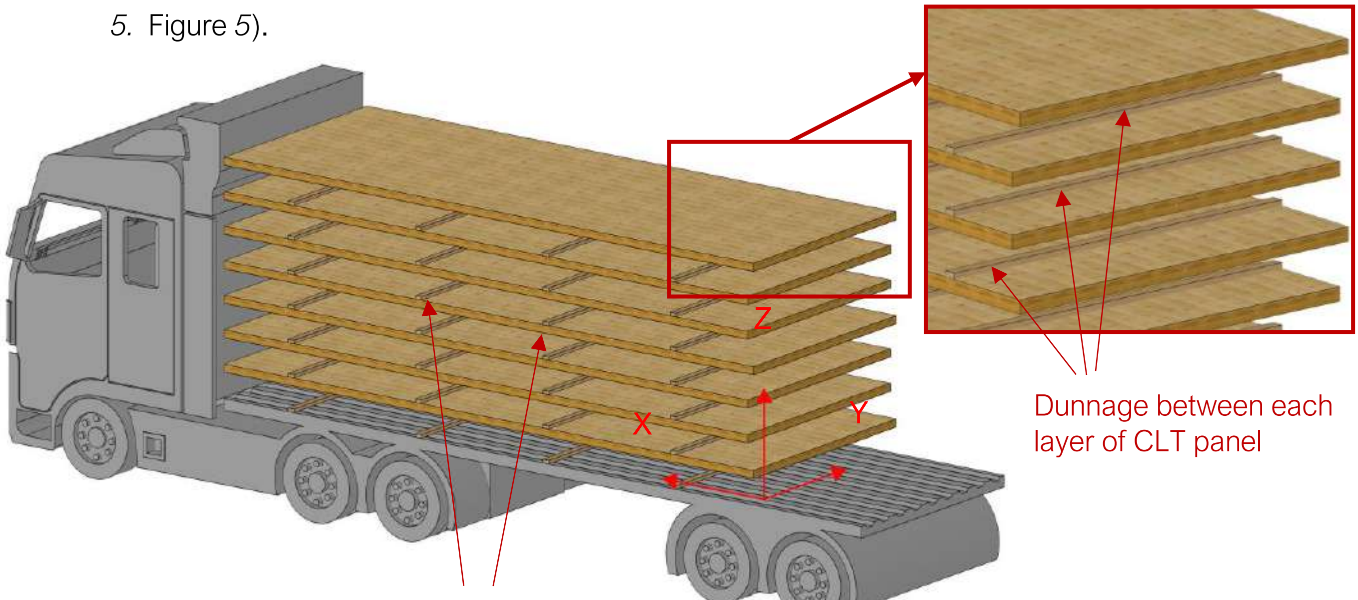


Figure 5: Example of truck loading configuration

6. Elements greater than 3.0 meters are consolidated as much as practically possible into oversized bundles to reduce the number of loads that require piloting (the maximum width without piloting is 3.1 meters; however, this includes tie downs and overall angling across the Y-axis, therefore Red Stag generally limit to 3.0 meters) unless directed otherwise by the Client.
7. Truck loading bundles are generally limited to a maximum of 3.0 meters in height (Z-axis) including dunnage (the bottom bearers/dunnage are typically 0.15 meters to allow for a 40 MT forklift to load, and bundles typically have ~45 mm (20 – 50 mm) dunnage in between each element layer); however, may need to be reduced to 2.8 – 2.9 meters for certain transportation unit bed heights. **Note:** The maximum total system transportation height from road surface to the top of the load is 4.25 m unless permitted otherwise (permit and piloting).

5. Red Stag Shop Drawing Timeline

Shop drawings can only commence after the following has been completed:

I. The Red Stag quotation has been signed by the Client with a mutually agreed project timeline and counter signed by Red Stag.

II. The project deposit has been paid in full as defined in the quotation payment terms.

III. The shop drawing charges have been paid in full (unless otherwise detailed in the quotation).

IV. All documents are received as defined in *Section 1.3* (Requirements).

V1.0 of the shop drawings can only be release to the Client for review once the shop drawing tranche (refer to quotation) has been paid in full.

The timeline for completing shop drawings is directly proportionate to the scale and complexity of the project. Depending on the complexity, and demand on the Red Stag shop drawing team, the general timelines to complete shop drawings for standard to medium complexity projects are as follows:

1. The Shop drawing process will typically commence within 10 business days following steps I to III above.
2. The first iteration of the shop drawings will generally take:
   - 2.1. 10 to 12 business days to complete up to 150 m^3.
   - 2.2. 15 business days to complete the first iteration up to 300 m^3.
   - 2.3. 20 business days to complete the first iteration up to 500 m^3.
   - 2.4. 25 business days to complete the first iteration up to 700 m^3.
   - 2.5. 30 business days to complete the first iteration up to 1,000 m^3.
3. Client shop drawing review of Revision V1 (first iteration supplied by Red Stag) is expected to be completed between 5 to 10 business days for projects up to 500 m^3 and between 10 to 15 business days for projects larger than 500 m^3.
4. Subject to no design changes, clearly highlighted change requests and associated documentation, Red Stag will schedule to make all necessary changes to Revision V1 within 5 to 10 business days and issue as Revision V2.
5. Client shop drawing review of Revision V2 is expected to be completed within five business days for projects up to 500 m^3 and up to 10 business days for projects larger than 500 m^3.

Dependent on the scale of the project, Red Stag will generally schedule to issue shop drawings with the preliminary truck loading plan within five (5) business days after the Client confirms and signs off the shop drawings. The expectation is that all truck loading plans will be finalised with the client within five (5) business days of issuance and be completely signed off by the Client on Red Stag paperwork (refer to *Appendix* B and *C*) to allow for manufacturing to commence thereafter at Red Stag's discretion.

Prior to issuing the shop drawings, the Client project consultants must advise Red Stag on who is the primary project consultant that Red Stag is to liaise with on the shop drawing process. This process is managed via the *Red Stag Project Drawing Acceptance Form* (refer to *Appendix* A). The process allows for the project consultants to advise who is authorised within the Client team to sign off on the shop drawings.

6. Review Process

If all payment schedules are up to date, Red Stag will issue Revision V1 of the shop drawings as soon as they have been completed to the Client project consultants for review.

Red Stag generated shop drawings must be reviewed by the Client project consultants to ensure that all EWP elements are fit for purpose, correctly reflect the requirements for the project and that all dimensional properties are accurate and include all required design aspects. The Client project consultants' responsibilities include, but are not limited to the confirmation/sign off or marking up of all required amendments such as all element:

1. Dimensions.
2. Grades (i.e., Standard, Visual, Architectural).
3. Grain directions.
4. Recipe configuration.
5. Thicknesses.
6. Treatments.
7. Penetration positions.
8. Machining tolerances.
9. Joints, penetrations and machining/processing are correct and align with the project requirements (i.e. precise positioning, processing details, tolerances, etc).

Red Stag will commence working on Revision V2 of the shop drawings as soon as practically possible after receiving all marked-up comments and drawings related to Revision V1 from the Client project consultants.

It is essential that all mark ups are clearly and uniquely identified prior to Red Stag working on Revision V2 to expedite the process and remove ambiguity or missed requirements.

Following adequately marked up Revision V1 drawings, Red Stag will commence the updating of Revision V2 as soon as practically possible. Following the completion of Revision V2 shop drawings, Red Stag will issue to the Client project consultants.

The Client project consultants are then required to complete the process again for Revision V2. If everything is in order with Revision V2, the authorised Client project consultant is to sign off on the shop drawings on the *Red Stag Project Shop Drawing Approval Form* (refer to *Appendix B*) prior to Red Stag proceeding with developing the truck loading sequence. The shop drawing process and associated charges in the quotation only allow for two iterations/revisions of the shop drawings. If additional shop drawing iterations are required (outside of errors or omissions from Red Stag), additional charges will apply, and the project schedule may be adversely impacted. If the impact to the timeline is due to the Client project consultants, then it is up to the Client project team to compress elements inside their control or automatically accept an increase to the overall project timeline. Red Stag will use best endeavours to support in compressing timelines but is not responsible for delays outside of its control (delays to the schedule in the shop drawing phase do not create a linear delay to the overall manufacture and supply process for EWP).

The review process of Red Stag shop drawings is crucial to ensure that the Client expectations for the supply of the EWP elements are met.

After the shop drawings are formally approved by the Client project consulting team, Red Stag will commence working on the truck loading plan and associated element lifting details. As soon as the proposed truck loading and lifting programme is completed, it will be issued to the authorised Client representative for review and sign off. Amendments can be expediently worked through during this process, noting the criteria detailed in *Section 4*. The Client authorised representative must sign off on the truck loading and lifting details on the *Red Stag Project Lifting & Scheduling Approval Form* (refer to *Appendix* C) before the entire shop drawing review process can be finalised. If the shop drawing process is not finalised (including the required sign off on Red Stag documents by the Client authorised representative), the manufacturing process cannot commence.

To formalise the Client acceptance of the entire shop drawing processes described above, the authorised Client project consultant must sign off on both the *Red Stag Project Shop Drawing Approval Form and the Red Stag Project Lifting & Scheduling Approval Form* (refer to *Appendix B and* C).

When the Client project team sign off on the entire shop drawing process, the Client team accept that Red Stag can commence manufacturing ahead of the required project schedule at Red Stag's discretion.

Any changes to the shop drawings after the sign off process has been completed will incur additional shop drawing charges. Any re-processing or replacement elements required due to Client generated changes or errors to already manufactured elements will incur additional charges at the EWP rates at the time of replacement/re-processing.

Any post sign off changes may adversely impact the project timeline; however, Red Stag will use best endeavours to minimise the impact to the Client. Please note that the impact of the timeline is generally not linear.

By signing off the shop drawings, truck loading and lifting documents, the Client agrees that Red Stag can commence manufacturing anytime thereafter. Red Stag will not accept any waiver or liability for any incorrect details in the shop drawings. This includes but is not limited to: recipes, grading, treatment, dimensions, lifting points, lifting solution design, lifting mechanism, transportation plan, etc.

Any delays to the pre-shop drawing and shop drawing processes (including Client completing Red Stag paperwork, review and sign off) by the Client will adversely impact the overall programme schedule. Impacts to the schedule are not linear, therefore a delay, may cause the project to miss its allocated and agreed production window at Red Stag. This may require the project to transition to the next available production window. This could cause weeks or even months of delays for the Client, therefore it is essential that the shop drawing process is completed as early as practically possible, and the overall allocated manufacturing schedule is maintained.

Red Stag will always use best endeavours to support Clients to minimise delays. Project delays outside of Red Stag's control could also cause price escalation associated with inflated costs (e.g. increased raw material costs, increased labour costs, etc). An infographic example for the Red Stag shop drawing process timeline is summarised in *Figure 6*.

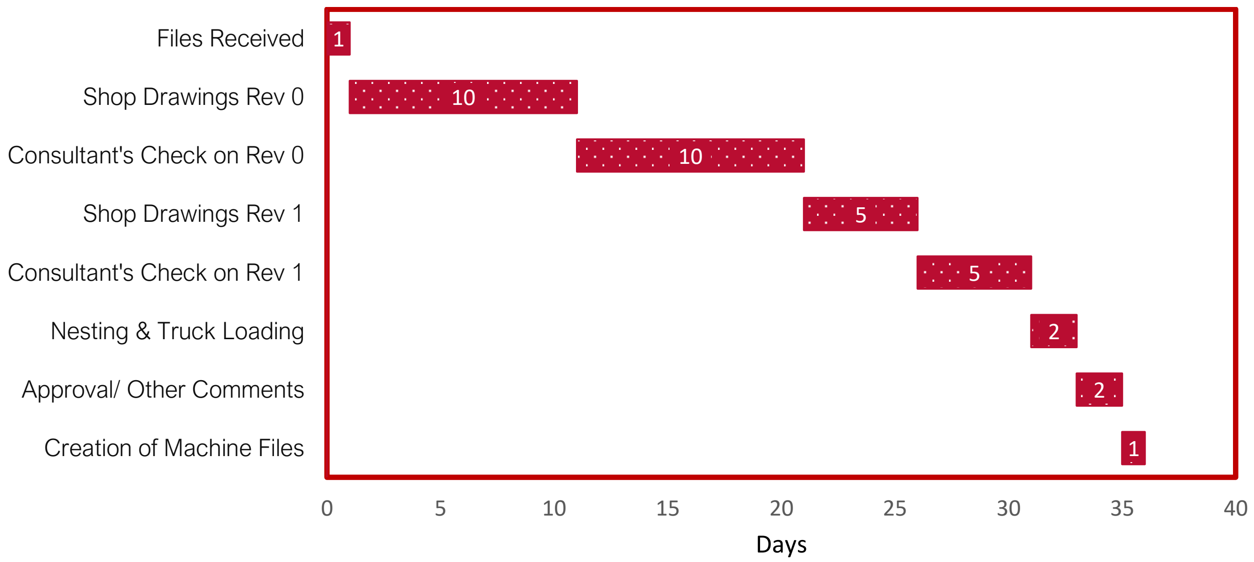


Figure 6: Representation of a Red Stag shop drawing timeline.

7. Red Stag Shop Drawing Example

Figure 7: Example of a Red Stag shop drawing cover sheet.

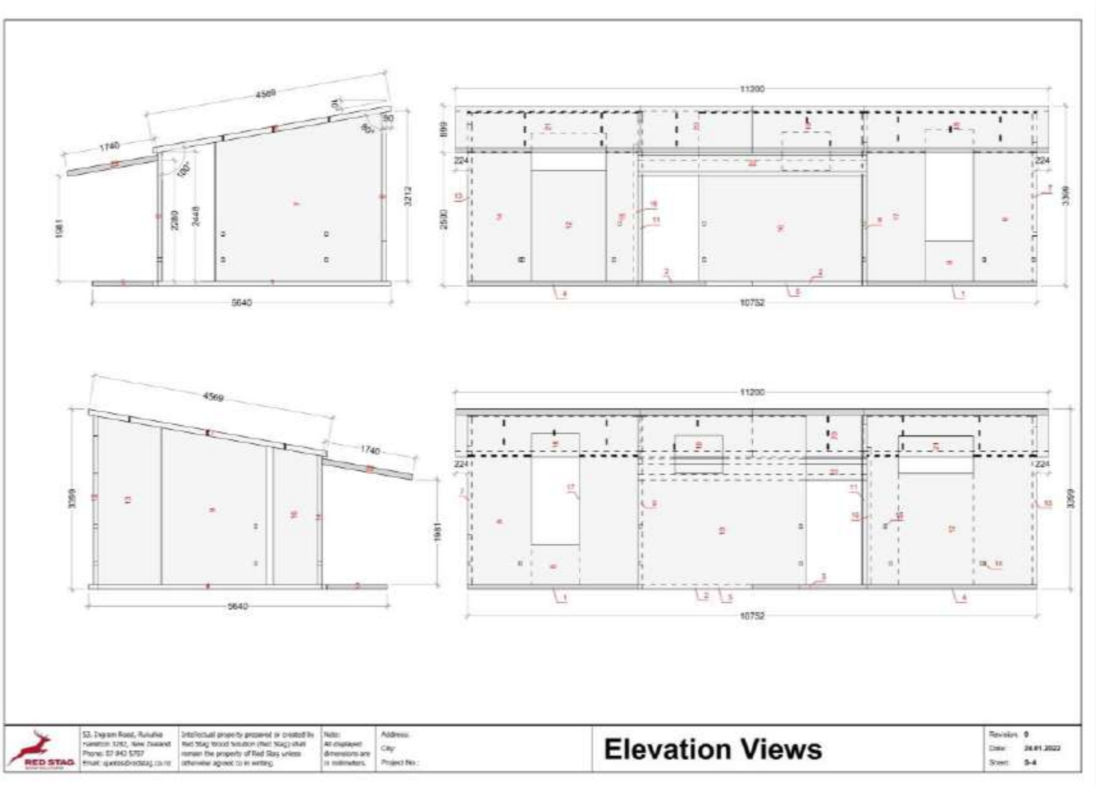


Figure 8: Example of Red Stag shop drawing elevations.

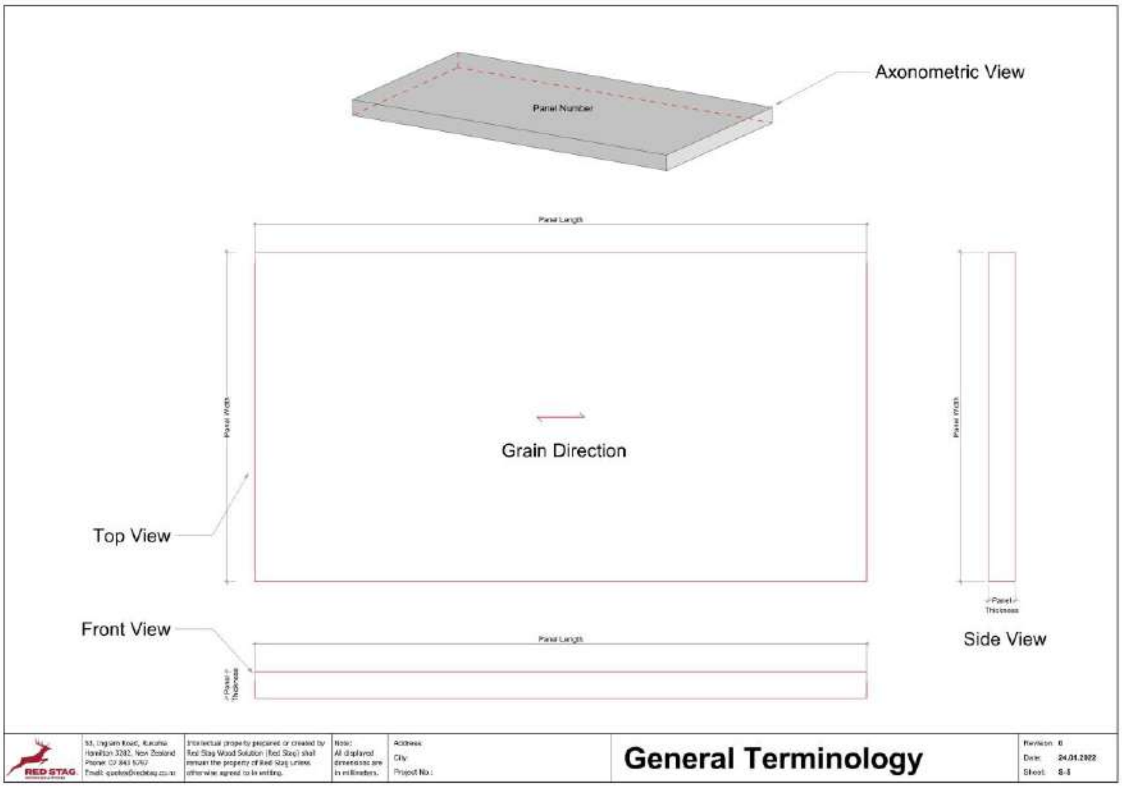


Figure 9: Red Stag shop drawing general terminology.

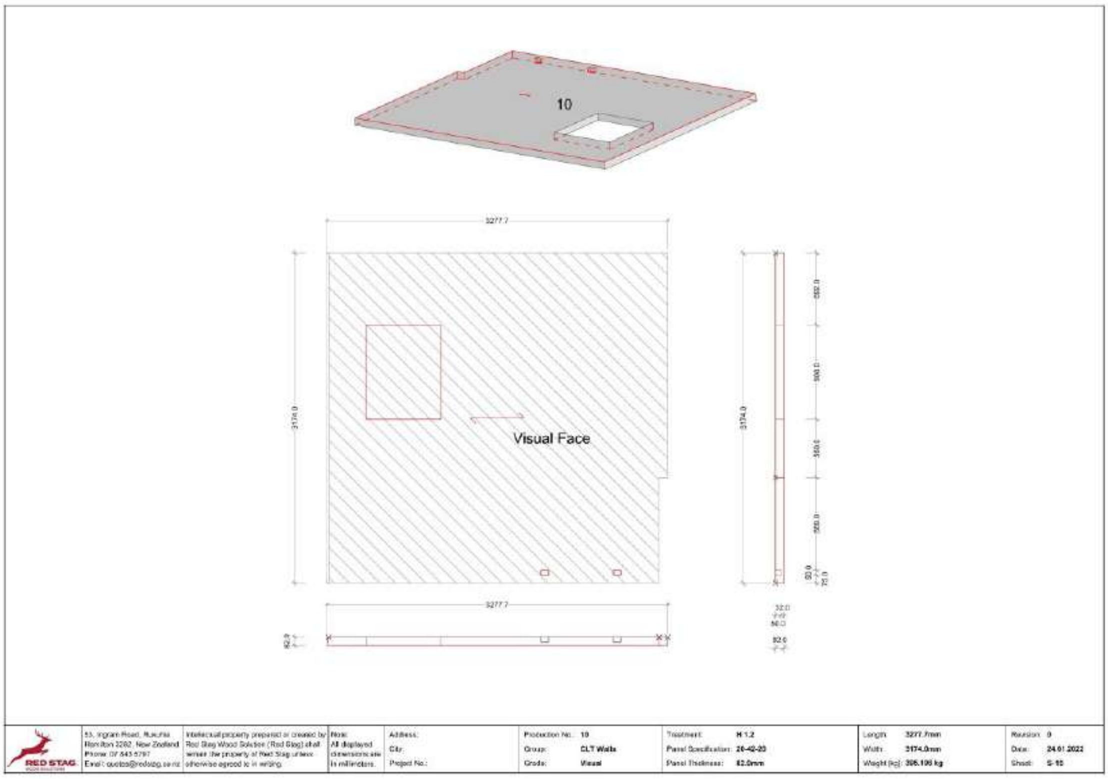


Figure 10: Example of Red Stag shop drawing element drawings.

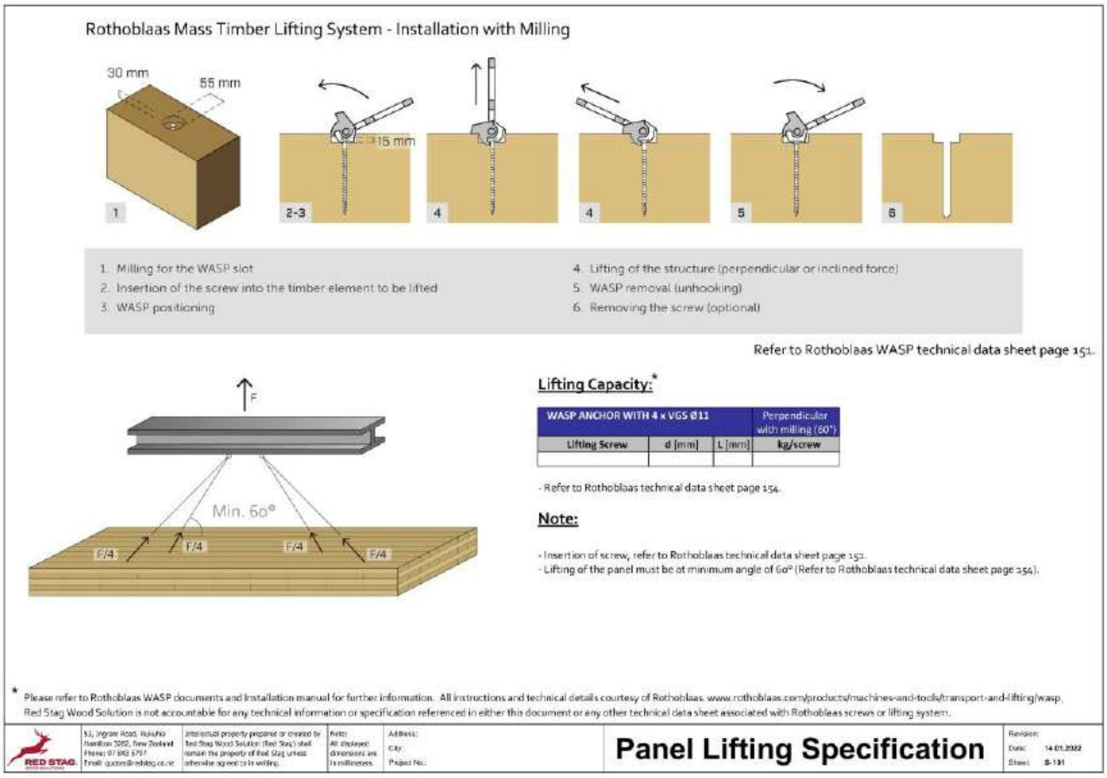


Figure 11: Example of lifting system option (Client must confirm acceptance).

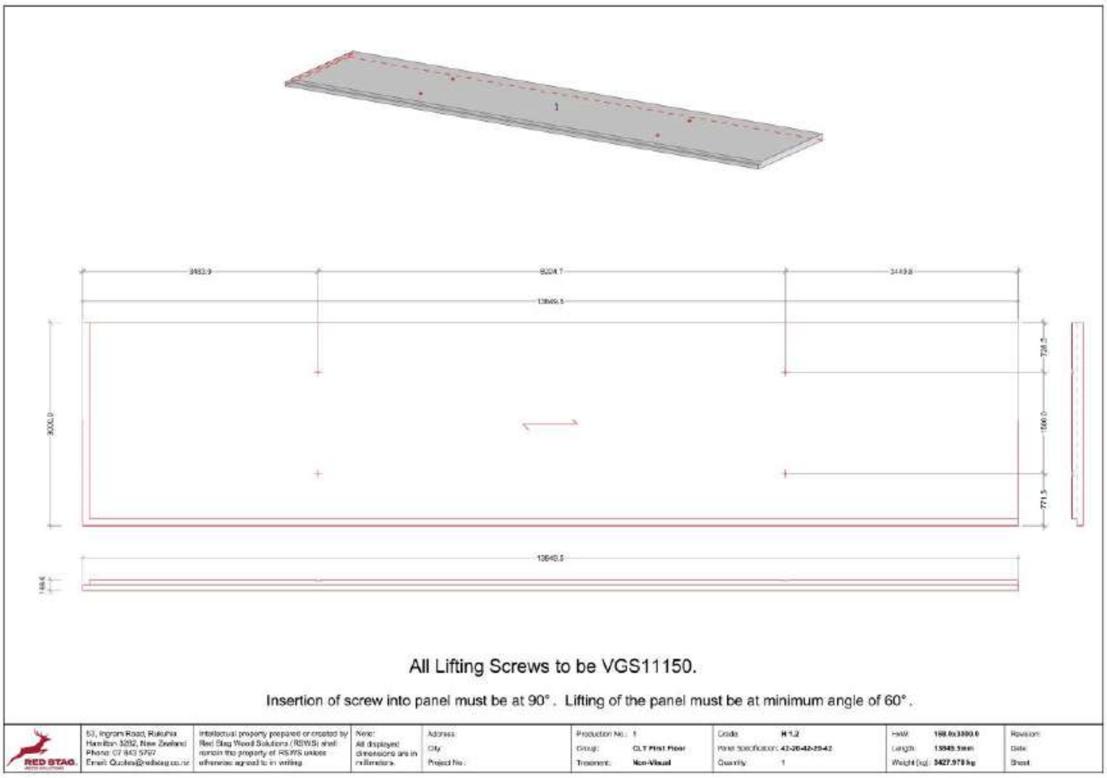
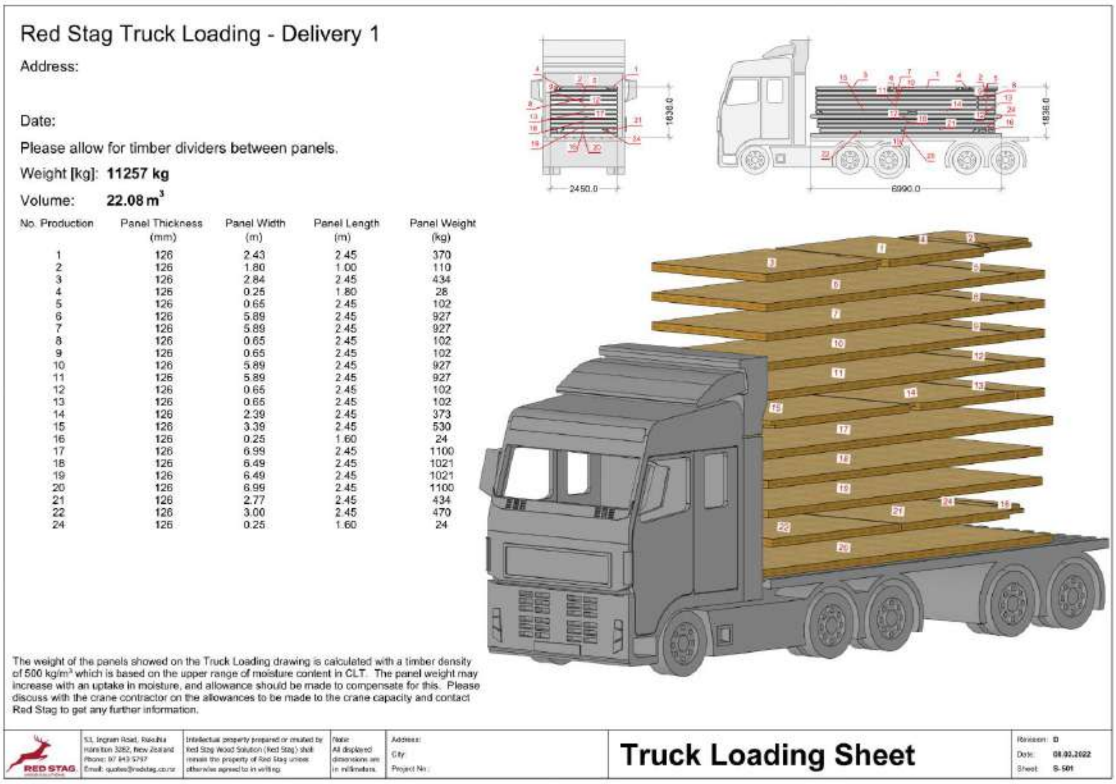


Figure 12: Example of lifting point drawing (Software suggested lift points - Client to confirm).



Red Stag Truck Loading - Delivery 1

Address:

Date:

Please allow for timber dividers between panels.

Weight [kg]: **11257 kg**

Volume: **22.08 m^3**

No. Production	Panel Thickness (mm)	Panel Width (m)	Panel Length (m)	Panel Weight (kg)
1	126	2.43	2.45	370
2	126	1.80	1.00	110
3	126	2.84	2.45	434
4	126	0.25	1.80	28
5	126	0.65	2.45	102
6	126	5.89	2.45	927
7	126	5.89	2.45	927
8	126	0.65	2.45	102
9	126	0.65	2.45	102
10	126	5.89	2.45	927
11	126	5.89	2.45	927
12	126	0.65	2.45	102
13	126	0.65	2.45	102
14	126	2.39	2.45	373
15	126	3.39	2.45	530
16	126	0.25	1.60	24
17	126	6.99	2.45	1100
18	126	6.49	2.45	1021
19	126	6.49	2.45	1021
20	126	6.99	2.45	1100
21	126	2.77	2.45	434
22	126	3.00	2.45	470
24	126	0.25	1.60	24

The weight of the panels showed on the Truck Loading drawing is calculated with a timber density of 500 kg/m^3 which is based on the upper range of moisture content in CLT. The panel weight may increase with an uptake in moisture, and allowance should be made to compensate for this. Please discuss with the crane contractor on the allowances to be made to the crane capacity and contact Red Stag to get any further information.

RED STAG

53, Ingram Road, Rukuhia
Hamilton 3282, New Zealand
Phone: 07 843 5797
Email: quotes@redstag.co.nz

Intellectual property prepared or created by Red Stag Wood Solution (Red Stag) shall remain the property of Red Stag unless otherwise agreed to in writing.

Note: All displayed dimensions are in millimeters.

Address:
City:
Project No.:

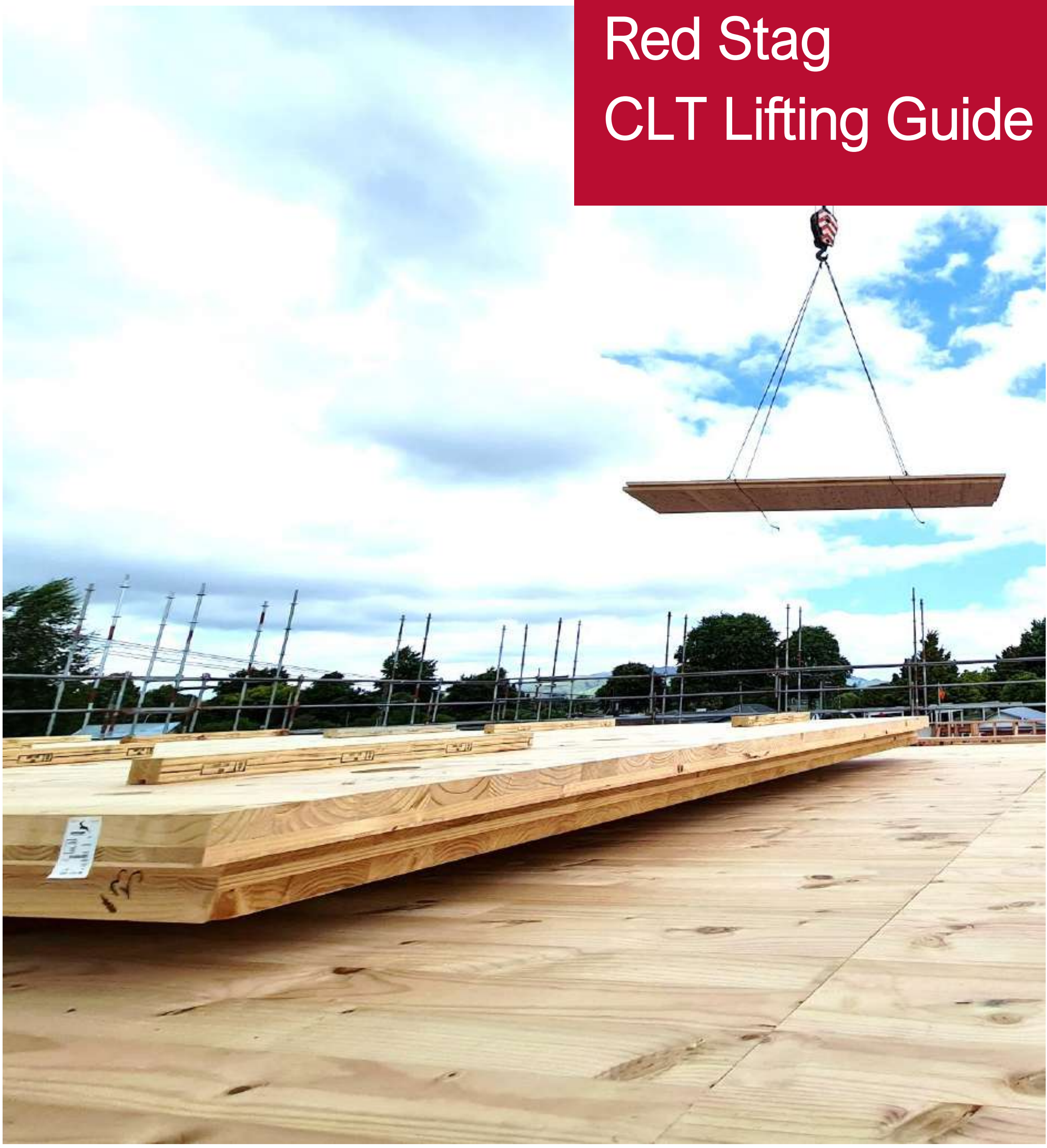
Truck Loading Sheet

Revision: D
Date: 08.03.2022
Sheet: S-501

Figure 13: Example of truck loading drawing (Red Stag truck loading sheet).

Section 2

Red Stag
CLT Lifting Guide



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RED STAG WOOD SOLUTIONS

8. CLT Lifting Overview

The Red Stag lifting guide has been developed to provide Client's with options to lift EWP element such as CLT and GLT. This lifting guide represents commonly used EWP lifting solutions used through Europe. The guide is intended as a guide only and it is responsibility of the Red Stag EWP Client's and users to ensure the suggested EWP lifting solution is fit for purpose and appropriate for the Client's needs. Client's and users need to exercise their own professional judgment when using this guide, and sign off on all lifting solutions suggested or supplied by Red Stag.

Screwed anchor lifting points are the commonly recommended lifting method for Red Stag EWP elements (refer to *Figure 14a* and *Figure 14b*). Red Stag CLT floor and wall elements are typically lifted horizontally and vertically respectively.

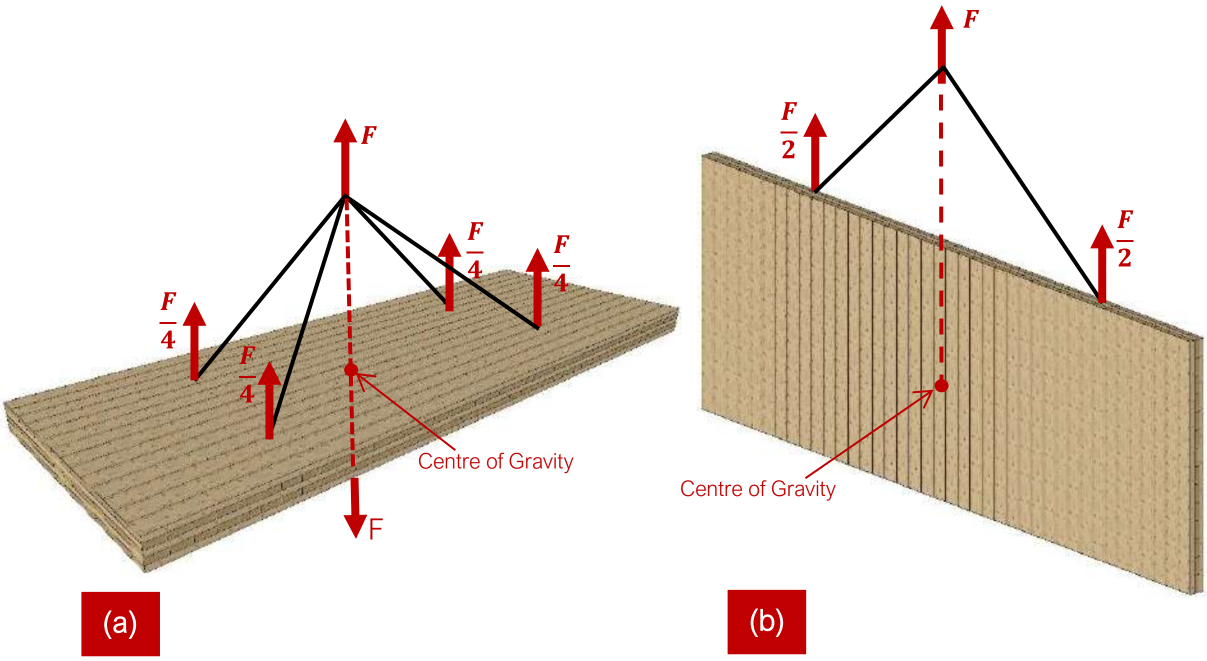


Figure 14: Typical lifting system; a) CLT floor lifting system, b) CLT wall lifting system.

There are several lifting techniques for screwed anchor lifting points that rely only on the withdrawal resistance of fasteners. Although these techniques are simple and effective, they require a careful design analysis for the loads involved and strict control during installation and use/lifting. Another advantage of a screwed anchor lifting systems is that they have a very minor effect on the appearance of the timber elements, which is especially important for visual grade elements.

The screwed anchor system comprises of two components: the lifting screw (*Figure 15a*) and the lifting hitch (*Figure 15b*). It is essential that the two components are specifically designed and rated for the application. It is recommended that the lifting screws are only used once to ensure that they perform as rated. Red Stag has partnered with Rothoblaas in Italy for their proprietary screwed anchor lifting system.

Depending on application and design of the elements, self-tapping screws could penetrate at an angle between 30 to 90 degrees to the lifting face of the EWP element. A further advantage of the screwed anchor system is the speed to connect the lifting hitches and lift the elements. *Figure 16* illustrated the connection hitch to screw ready for lifting.

Figure 15: Screwed anchor lifting system.

Figure 16: Screwed anchor lifting components.

Depending on the size and mass of the element being lifted, between 2 – 12 lifting screws may be required. The gauge, length, and screw type (partially or fully threaded), combined with the dimensions and mass of the element support in determining the number of required screw anchors. It is essential that the angle of each screw and hitch to the element are managed to ensure that the lifting performance of each screwed anchor and system has sufficient lift capacity for the intended lift (including safety factor). If managed correctly (based on the criteria above), it is possible to lift up to 75 m^2 with as few as eight screw anchors (refer to *Figure 17*and *Figure 18*).

Figure 17: Installation shows an example of a 75 square meter Red Stag CLT panel being effortlessly installed on site. 16.5 m x 4.5 m Red Stag CLT floor panel is lifted via eight screw anchor lifting points.

Figure 18: Red Stag CLT midfloor over the Red Stag light timber framing (Red Stag has a frame and truss manufacturing plant in Hamilton, New Zealand that can integrate supply into a hybrid mass and light timber project).

9. Design and Technical Lifting Principal

The lifting angle (β) has a significant influence on the load-bearing capacity of a screw anchor lifting system (refer to

Figure 19).

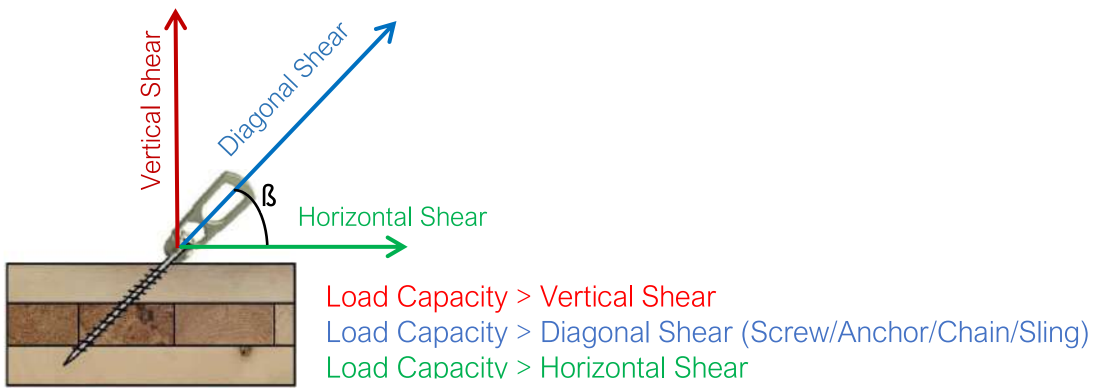


Figure 19: Lifting capacity reduction based on angle of lift.

Figure 20 to Figure 21 illustrate a range of common screw anchor lifting examples for mass timber floors and walls. Red Stag mass timber elements are typically delivered horizontally. To transition wall elements to a vertical plane, the lifting system needs to be checked to confirm load-bearing capacity of the selected lifting system works in both directions (refer to *Figure 21*).

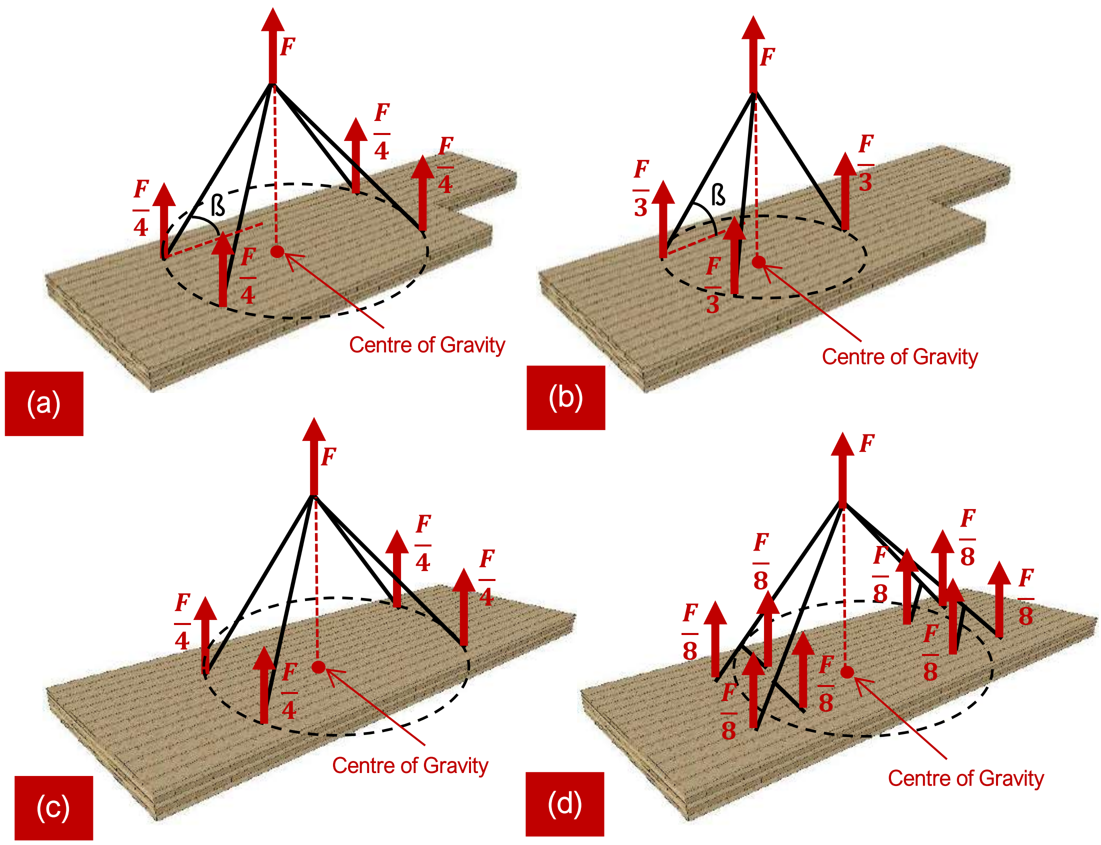


Figure 20: Examples of screw anchor lifting methods for CLT floors.

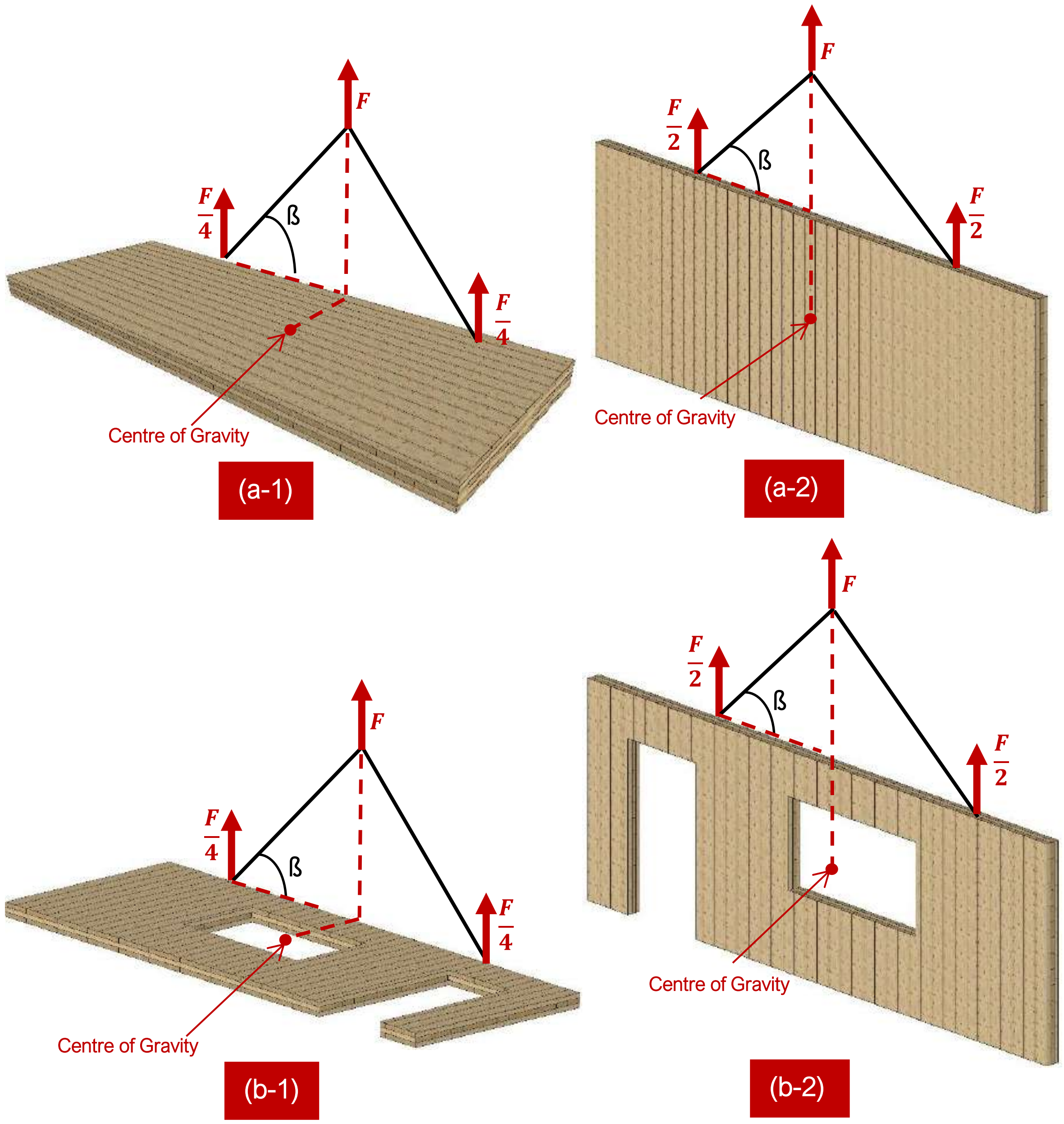
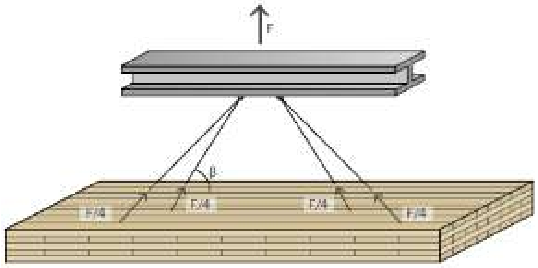


Figure 21: Examples of screw anchor lifting methods for CLT walls; a-1 and a-2 illustrate lifting a wall panel with no openings. b-1 and b-2 represent lifting a wall panel with openings.

The screw capacity of a screw anchor lifting system with varying screw and lift angles is summarised in *Table 1 to Table 4*. As per the details in *Table 1 to Table 4,* the highest lifting capacities are achieved with the screw loaded in diagonal tension in conjunction with a 55 mm diameter milled recess to support the lifting hitch (refer to *Figure 22*). Non-recessed anchor screw lifting configurations in conjunction with WASP lifting hitches are presented in *Figure 23* and *Figure 24*.

Table 1: Screw and anchor lifting capacity with four lifting points [a, 1]

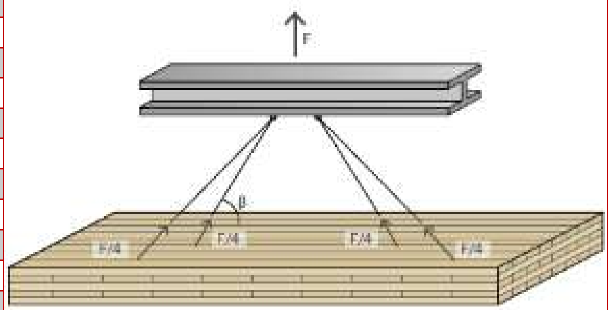
Screw Type	Penetration angle	Perpendicular	Perpendicular with milling	Inclined
	ß°	R_d kg	R_d kg	R_d kg
4 Ø11×100	30	501	1353	803
	45	828	2243	1586
	60	1270	2243	1943
	75	1852	2243	2167
	90	2243	2243	2243
4 Ø11×150	30	769	1353	1376
	45	1275	2343	2644
	60	1993	3739	3238
	75	3013	3739	3612
	90	3739	3739	3739
4 Ø11×200	30	926	1353	1949
	45	1553	2343	3701
	60	2476	3058	4533
	75	3962	5122	5056
	90	5234	5234	5234
4 Ø11×250	30	931	1353	1949
	45	1581	2343	3749
	60	2600	4058	4592
	75	4512	5122	5122
	90	5302	5302	5302



[a] Refer to Rothoblaas Documents: WASP hook for timber element transport.

Table 2: WASP Anchor system capacity with four lifting points for horizontal CLT Floors [a, 1]

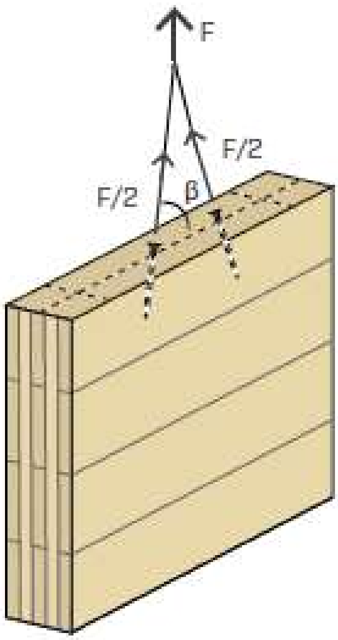
Screw Type	Penetration angle	Perpendicula	Perpendicula with milling	Inclined
	ß°	R_d kg	R_d kg	R_d kg
4 Ø13×100	30	579	1691	949
	45	956	2651	1875
	60	1473	2651	2296
	75	2178	2651	2651
	90	2651	2651	2651
4 Ø13×150	30	888	1691	1626
	45	1481	2928	4374
	60	2315	5072	5357
	75	3527	6186	5975
	90	4419	6186	6186
4 Ø13×200	30	1195	1691	2304
	45	2002	2928	4374
	60	3144	5072	5357
	75	4856	6186	5975
	90	6186	6186	6186
4 Ø13×300	30	1226	1691	3659
	45	2104	2928	6874
	60	3506	5072	8419
	75	6234	9721	9390
	90	9721	9721	9721



[a] Refer to Rothoblaas Documents: WASP hook for timber element transport.

Table 3: *WASP Anchor system capacity with two lifting points for vertical CLT Walls* [a, 1]

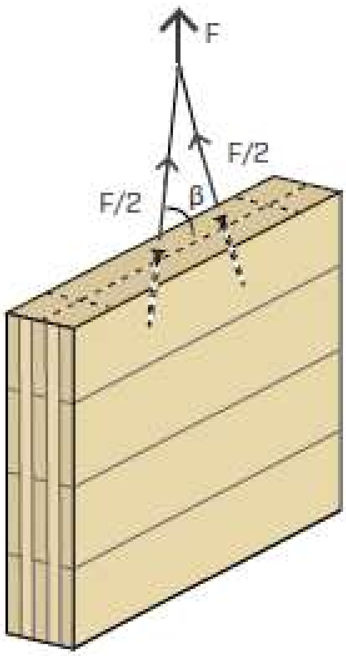
Screw Type	Penetration angle	Perpendicular	Perpendicular with milling	Inclined
	ß°	Rd kg	Rd kg	Rd kg
2 Ø11×100	30	110	676	362
	45	188	770	545
	60	305	771	668
	75	524	771	745
	90	767	771	771
2 Ø11×150	30	168	676	588
	45	288	1171	863
	60	470	1221	1057
	75	815	1221	1179
	90	1219	1221	1221
2 Ø11×200	30	226	676	805
	45	389	1171	1168
	60	633	1652	1431
	75	1101	1652	1596
	90	1650	1652	1652
2 Ø11×250	30	284	676	1015
	45	488	1171	1465
	60	795	2029	1794
	75	1382	2072	2001
	90	2068	2072	2072
2 Ø11×300	30	307	676	1221
	45	528	1171	1755
	60	868	2029	2149
	75	1557	2482	2397
	90	2481	2482	2482



[a] Refer to Rothoblaas Documents: WASP hook for timber element transport.

Table 4: *WASP Anchor system capacity with two lifting points for vertical CLT Walls* [a, 1]

Screw Type	Penetration angle	Perpendicular	Perpendicular with milling	Inclined
	ß°	Rd kg	Rd kg	Rd kg
2 Ø13×100	30	122	828	414
	45	210	881	623
	60	342	881	763
	75	592	881	851
	90	881	881	881
2 Ø13×150	30	187	845	920
	45	321	1395	987
	60	524	1395	1208
	75	918	1395	1348
	90	1395	1395	1395
2 Ø13×200	30	252	845	920
	45	432	1464	1335
	60	705	1889	1636
	75	1240	1889	1824
	90	1889	1889	1889
2 Ø13×300	30	381	845	1395
	45	655	1464	2006
	60	1069	2536	2457
	75	1864	2837	2740
	90	2837	2837	2837
2 Ø13×s400	30	401	845	1853
	45	690	1464	2652
	60	1155	2536	3248
	75	2144	3750	3622
	90	3750	3750	3750



[a] Refer to Rothoblaas Documents: WASP hook for timber element transport.

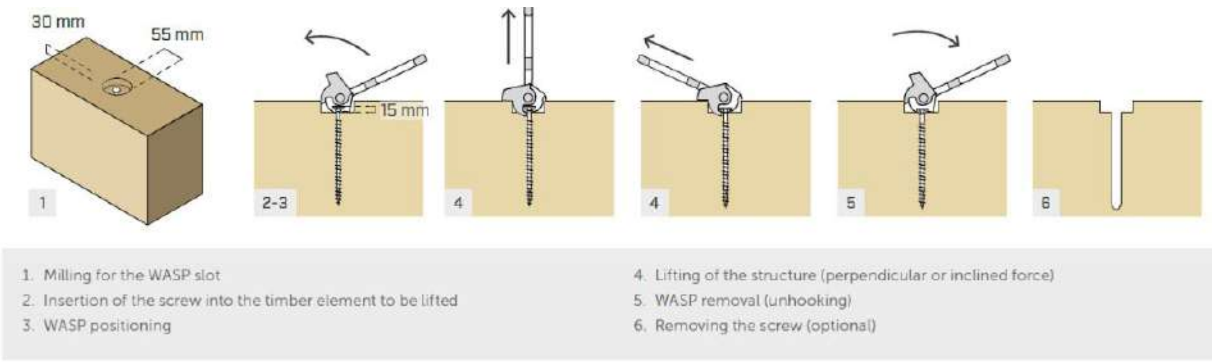


Figure 22: WASP installation with milling [1].

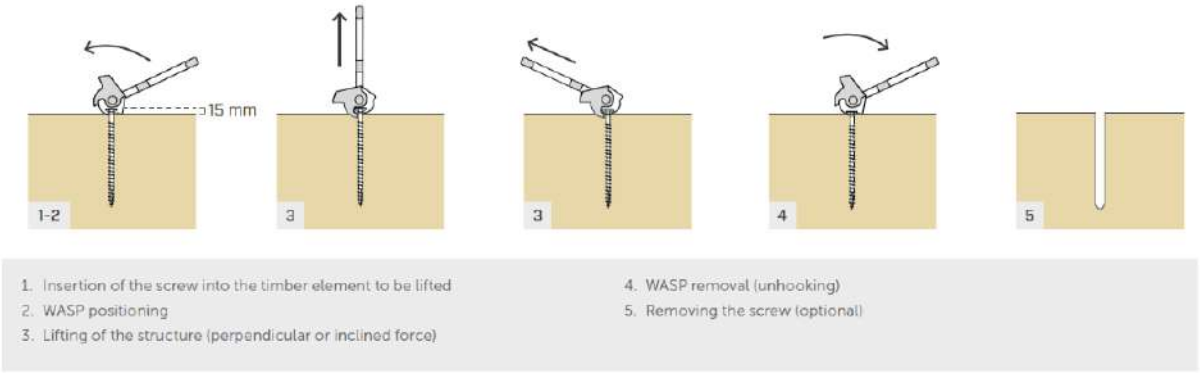


Figure 23: Perpendicular WASP installation without milling [1].

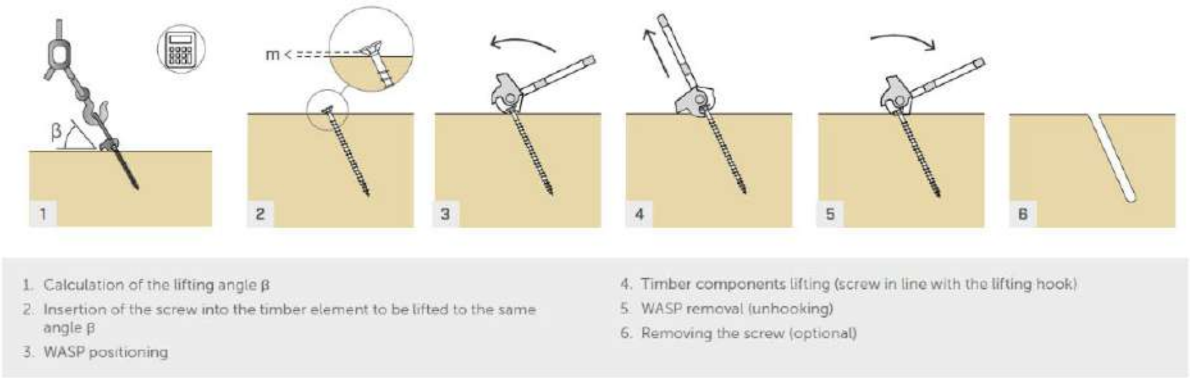


Figure 24: Inclined WASP installation without milling [1].

Figure 25 shows and example of the lifting documents that Red Stag provides for each project. It is responsibility of the Client to ensure that any suggested lifting methodology proposed by Red Stag is suitable for the specific project. Further details on lifting points are provided in the Reg Stag shop drawing documents. Based on Client requirements, Red Stag will regularly use fully threaded VGS Rothoblaas screws with milling to minimise the number of lifting points. As a general example, a 3 m wide, 8 m long 166 mm thick Red Stag CLT panel should only require four lifting points with recessed screw anchors (refer to *Figure 26*).

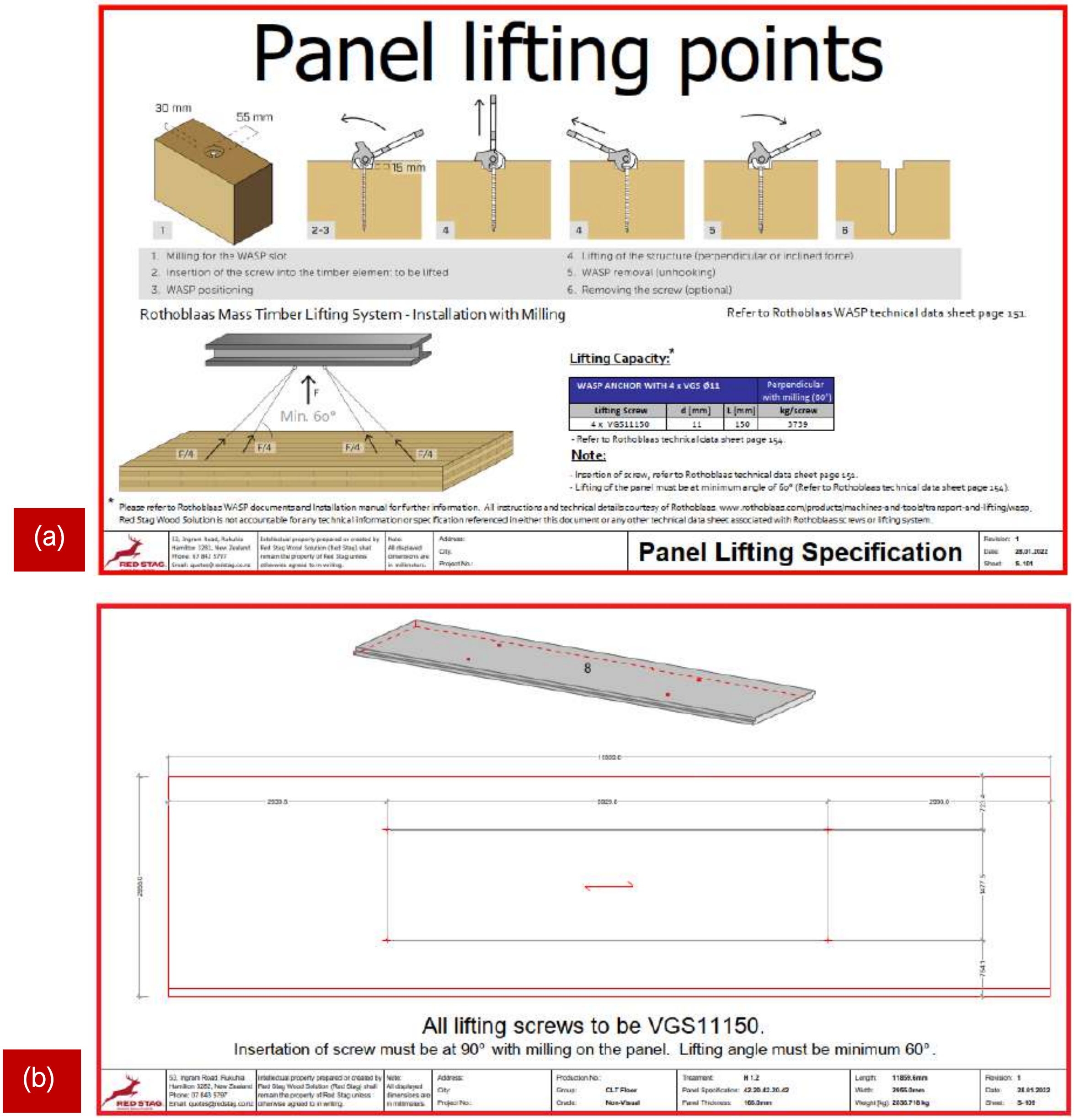


Figure 25: Example of Red Stag lifting documents; a) Cover sheet and specification page, b) Panel specification page.

Figure 26: Example of four-point lifting solution for a 3 m x 8 m Red Stag CLT panel.

It is recommended to use suitably sized spreader bars or similar when performing lifts. Spreader bars assist in ensuring that lifting rigging is always balanced, and evenly distributes the load on element fixing points. It is essential that the load on all fixing points is evenly applied when lifting (load cannot be applied to one lifting point more than others, otherwise there is a risk that the design criteria for the lifting point will be exceeded, and the lifting point may fail).

11. Lifting Safety Recommendation

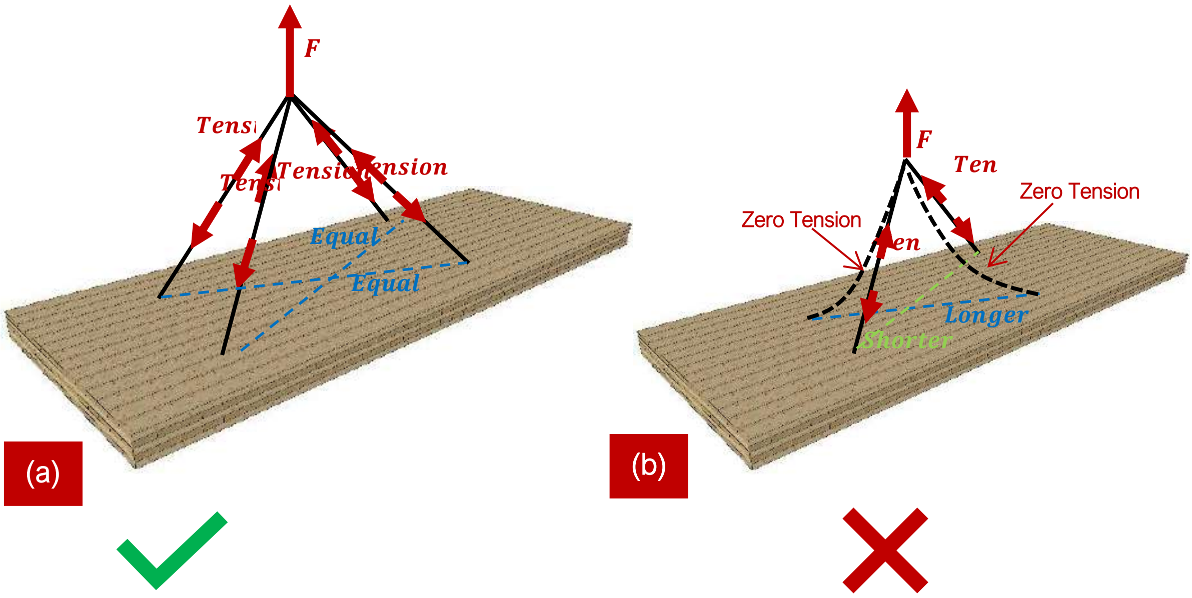
It is the responsibility of the Client and the contractor/equipment operator to take all the necessary care and precautions when determining, confirming, and undertaking a lift strategy for unloading and lifting Red Stag elements according to any applicable regulations, including but not limited to:

1. It is responsibility of the Red Stag EWP users to check and ensure that the provided Red Stag lifting documents for each project and project element are appropriate based on an average timber density of approximately 500 kg/m^3.
2. Identify and eliminate all potential hazards prior to and during any lifting process.
3. Red Stag EWP elements are to be lifted in restricted controlled lift zone(s) only. All lifts must be controlled and continuously supervised by the site safety officer and must be free of all people and hazards within the lift area.
4. No personnel, unnecessary vehicles, utilities, or any other at-risk item should be inside the lift zone during the lifting process (the lift zone must be sufficiently large enough to contain the lifted elements if they were to become detached for any reason).
5. Delivering transportation agents (e.g., truck drivers) are not responsible for lifting and offloading Red Stag EWP elements. Transportation agents should remain in their cab if it is safe to do so unless directed by the Site Safety Officer. Prior to any lifts, the transportation agent must ensure that transportation agents are in a safe designated area.
6. Only trained and experienced people in lifting the EWP elements should undertake lifting activities.
7. In addition to the Site Safety Officer, all associated personnel involved in the lifting process must ensure there is a suitable exclusion zone around and beneath the lifting area.
8. Before lifting any element or bundle(s), the Site Safety Officer must check that all equipment and components required in the lifting process are certified and appropriately rated, in a suitable condition and fit for purpose (refer to *Figure 27*).

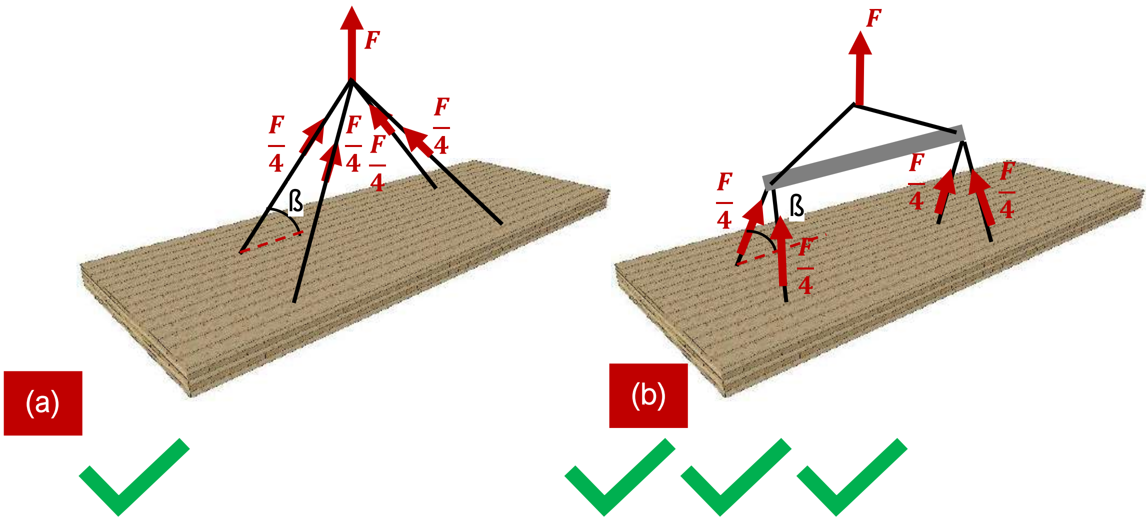
Figure 27: Site safety officer is checking all equipment and components related to the lifting process.

9. Ensure that only one assigned person is responsible for directing the lifting process (e.g., providing directions to the crane operator).
10. A “Stop” or “Halt” command can be given by anyone and must be obeyed instantly during any lifting process.
11. It is the lifting operator’s responsibility to establish the weight and centre of gravity of the load being lifted. The centre of gravity is the point at which a load, if suspended, is balanced and stable. The crane hook must be directly over the centre of gravity for the load to be stable. High wind conditions generally increase the hazards associated with the lifting process. The Site Safety Officer is responsible to check all environmental factors that may impact the lifting process. All parties (including the lift operators) must be comfortable with the weather conditions before the lifting process can continue.
12. Lifting operations must never be carried out during an electrical storm as a crane boom can become a lightning rod.
13. Lifting operations should generally not be carried out if there is a significant risk of high rainfall or a large snow fall as these can affect the stability of the ground conditions adversely impacting the stability of the crane.

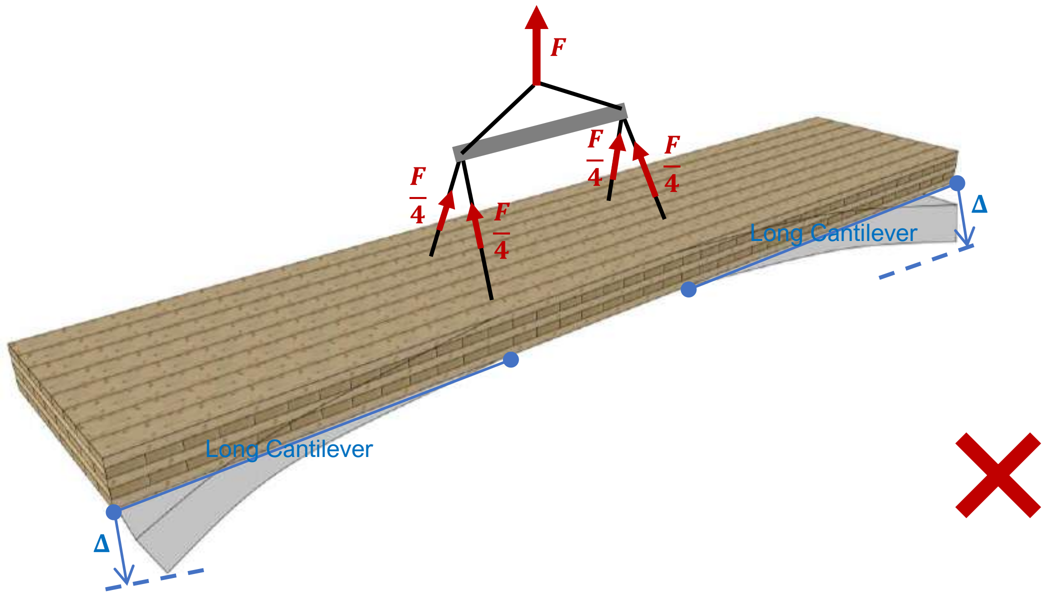
14. Lifting rigging (e.g. chains, strops, slings, shackles, hitches, WASPs, screws, etc) should be check before lifting. All applicable rigging should have equal lengths and be certified for the intended load(s).

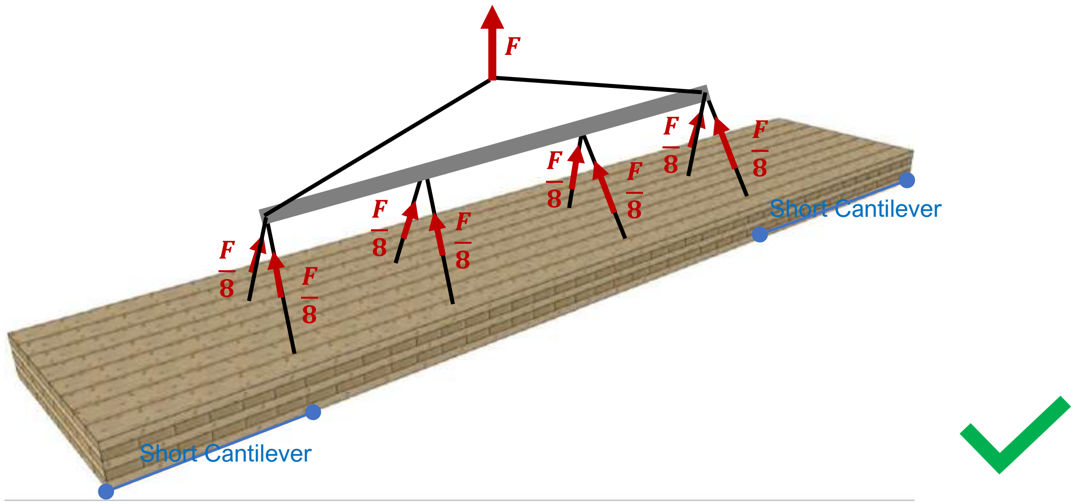


15. The use of lifting spreader bars is strongly recommended for lifting large or heavy panels. Please ensure all slings remain in tension.

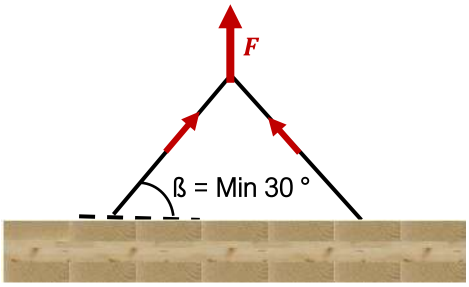


16. The use of a long spreader bar with multiple slings is strongly recommending for lifting long wall, floor, and roof panels.





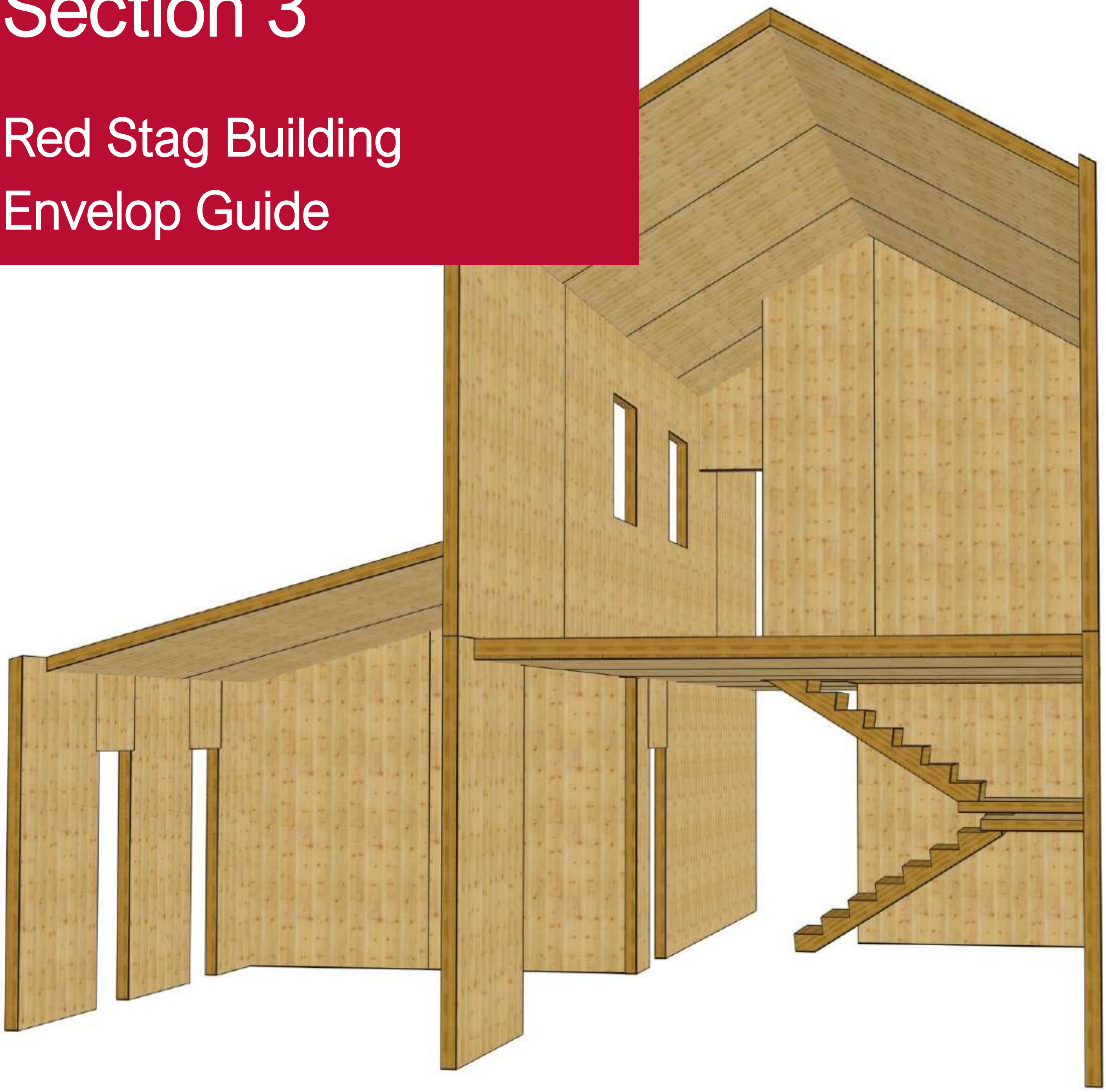
17. It is strongly recommended to maintain lift rigging angles more than 30 degrees.



18. Lifting rigging (e.g. spreader bars, chains, strops, slings, shackles, hitches, screws, etc) must be inspected for wear and damage prior to each lift. The lifting screws cannot be reused for a lifting application after their intended lift (one time use).

Section 3

Red Stag Building Envelop Guide



Make it better

Project Guide V1.0
August 2022

RED STAG
WOOD SOLUTIONS

12. Introduction

Mass timber buildings are constructed using a natural resource ‘wood’. Products that exist under the umbrella of mass timber include CLT and GLT, which are sensitive to changes in moisture conditions due to the fibrous nature of the timber.

The continual increase in demand for building performance standards (energy and moisture management) requires that building designers, manufacturers and construction-oriented professionals understand the challenges with various construction materials, including mass timber systems to maximise performance. Whilst the impacts of moisture ingress have gained notoriety in the media (Leaky buildings, Sick building syndrome, etc), there are some simple ways to ensure an effective design, flawless execution in construction, and ongoing maintenance programmes to prevent projects from becoming a focus for the wrong reasons.

12.1 What's a Building Envelope

The 'building envelope' is the separation between the interior and exterior of a building. The envelope serves to protect the interior while facilitating climate control. The building envelope encompasses the entire exterior building system, including windows, doors, roof, floor, and insulation. These three elements are the key factors in constructing the building envelope.

12.2 Tight and Loose Building Envelopes

A building envelope is normally referred to as either 'tight' or 'loose'. A loose envelope allows air to flow more freely through the building, whereas a tight envelope restricts air, or controls how it is admitted. New Zealand’s climate is such that tight envelopes are becoming the preferred choice. Innovations in the design and materials of exterior walls allow designers to take advantage of the environment and use the outside of the house to regulate the climate indoors.

12.3 Climate Control

There are several environmental considerations that should be considered when designing a building envelope. For comfort, a building should be well ventilated with fresh air, while being protected from strong winds and draughts. The entrance of damp air into a home in a humid or cold climate can encourage the growth of unhealthy mildew and mould. In climates that experience extreme temperatures, designers might select walls that will trap and release heat in response to external conditions as part of the building envelope.

Common challenges related to mass timber moisture management:

13.1 Ground Water

Ground water, or pooled water, on site can create a hazard for EWP. The proximity of a water source to EWP elements can have a significant impact on the dimensional stability of mass timber. EWP elements placed on bearers sitting above ground water (within 150 mm to 200 mm) can allow moisture to be drawn into the timber on one side.

If the timber members are then left in direct sunlight, the sunlight can draw moisture out of the panels on the exposed side, reducing the moisture content from its original 14% ± 2% (the optimal manufacturing moisture content). This can cause what is known as differential moisture effects. Panels, beams, and members can become distorted, sometimes rendering them unusable for the purpose they were intended. Ensure that timber elements are not exposed to direct sunlight for prolonged periods and are not stored over top of ground or pooled water (refer to *Figure 28*).

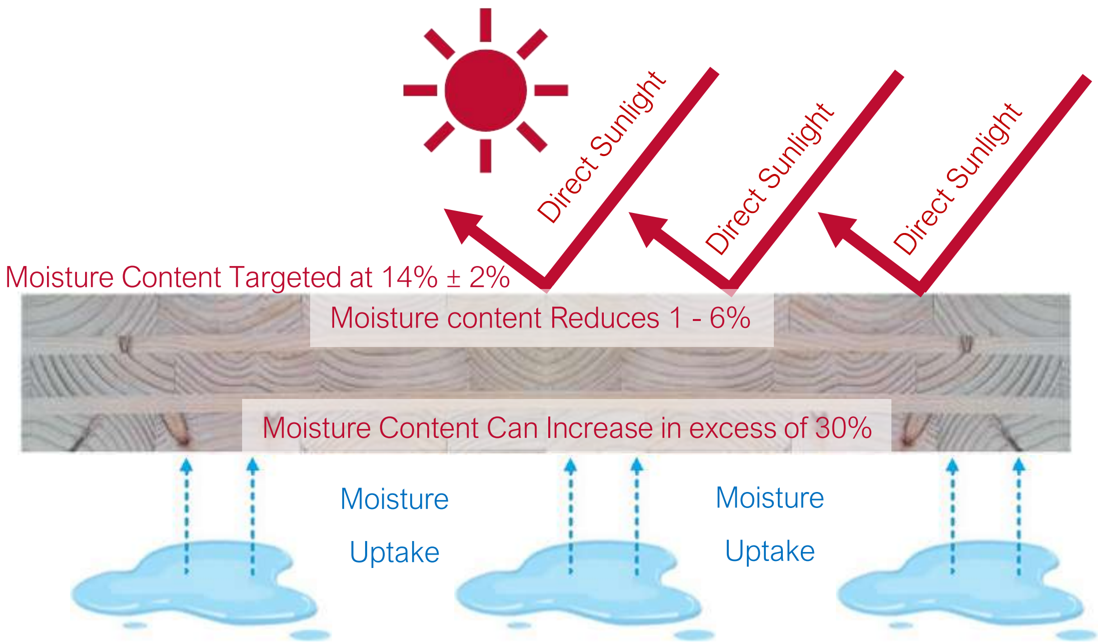


Figure 28: Differential Moisture Effects on Cross Laminated Timber.

13.2 Water Damage and Decay

Durability issues can be experienced with panels, members and entire sections of mass timber buildings due to exposure to, and the accumulation of excessive moisture (especially if the timber is not suitably treated). To heavily reduce the impact of decay, Red Stag treats all EWP feedstock (lamellas) to a minimum of H1.2 (boron) and can also treat to H3.2 (CCA). Moisture left unattended can impact the performance of the building and shorten its structural lifespan. At the very least, moisture ingress can cause swelling, providing a challenge during construction (more difficult to position panels into the correct location on-site and to ensure the dimensions of a building are accurate for other services and finishing).

13.3 Manufacturing Tolerances and Moisture

Timber is hygroscopic, which means it exchanges moisture with the atmosphere and localised environment. The prolonged exposure of timber to moisture, in any form, will result in dimensional changes to its initial state. Red Stag manufactures all EWP in a controlled environment with a targeted moisture content of 14% ± 2% (controlled in factory at the point of remanufacturing). The precision of Computer Numerical Controlled (CNC) processing requires that the moisture content remains relatively stable throughout the assembly and project lock-up stages.

There are several key principles that apply equally to conventional masonry, concrete, and mass timber structures. Whilst not applicable in New Zealand, the German wood preservation standard DIN 68800-2:2012-2[6] provides some important considerations for all jurisdictions constructing with mass timber. The DIN guidance stipulates a requirement for suitable measures to be taken to ensure the moisture content of buildings does not change unacceptably due to adverse influences, such as the previously mentioned issue of ground moisture, precipitation or drying out. The consequences of unacceptable swelling of timber components and the resulting changes in shape must be prevented by protection measures on building sites or through the planning of construction work.

14.1 Aesthetics and Moisture

Moisture may not only impact the dimensional characteristics of a built structure, but it may also significantly impact the visual appearance. Water can stain timber. Excessive moisture, and drying oscillations (dry/wet/dry/wet) can check the timber (make it crack and split). Visual defects such as water stains need to be mitigated, therefore weather protection is an increasingly important issue on timber construction sites (refer to *Figure 29 to Figure 31*).

Figure 29: Stains due to water ingress [2].

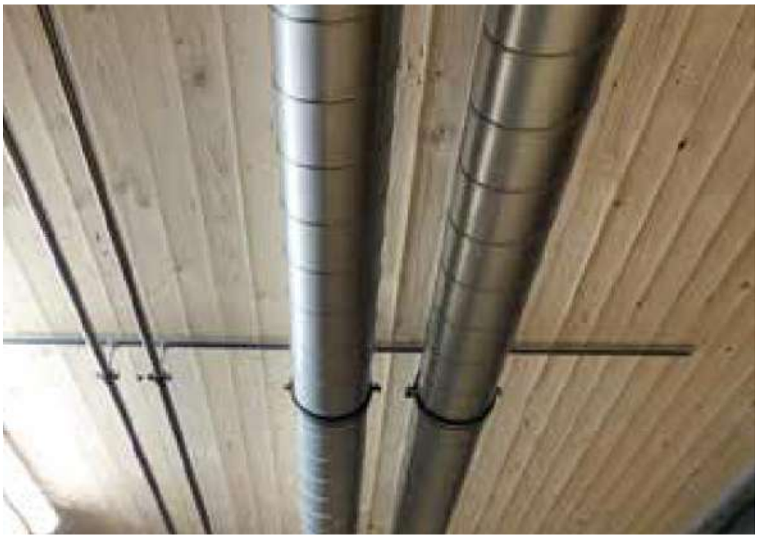


Figure 30: External lamella cupping due to excess water [2].

Figure 31: Leaking joint in mass timber [2].

15. Weather Protection During Construction

The application of temporary weather protection during the construction process is important for the protection of building elements. The use of temporary plastic sheets on the floor/ceiling surfaces to prevent or reduce their exposure to weather supports in mitigating the ingress of water. The use of sealing tapes, on the joint system(s) is another important mitigation technique. Temporary water protection acts as a run-off to remove water from the immediate impacts of moisture following rain and hail. The important consideration is that rainwater does not accumulate on exposed timber. The use of a water squeegee device, or a common broom, will support the removal of water settling in areas on the superstructure. This process must be undertaken immediately following a rain event to reduce the impact and risk of moisture ingress.

Manufacturers of protective membranes, such as Rothoblaas, Pro Clima, and Protor, recommend using a permanent wrap on the external walls (potentially pre-installed in the factory and delivered as semi-finished building elements to site), floors and roof systems on-site before inclement weather to provide the best practical mitigation of moisture. Full-surface adhesion membranes prevent moisture from spreading underneath the membrane if the membrane should be damaged during construction. The use of a sealing tape at the joints is a lower cost alternative to reduce joint moisture ingress but does not perform as well as a complete wrap system.

16. Permanent Building Wrap Envelope

The use of permanent wrap on building envelope elements is a requirement for the building solution. The application of an appropriate membrane (either in the factory or on-site prior to installation) provides protection for roof, wall, and floor elements in timber construction projects. Breathable membranes with full surface adhesion prevent moisture from spreading underneath the membrane if it becomes damaged during assembly. At timber element interfaces, at least 150 mm of membrane overlap should be provided onto the adjacent element. Timber surfaces that may have become damp can quickly dry out again thanks to the low diffusion resistance of suitable membranes

17. The Law of Four D's

17.1 Deflection

Rain deflection through design supports in minimising the impact of rainwater on the casing (sloping roofs, eaves, flashings, etc) [3].

17.2 Drainage

Design a drainage path with the aim of removing water from the building as quickly as possible (draining soil, sloped layers, porting to permanent or temporary waste pipes/spouting, etc) [3].

17.3 Drying

In properly designed buildings, water has a chance to evaporate, and moisture can escape from the layers [3].

17.4 Durable Materials

To further mitigate risk, Red Stag treats to a minimum of H1.2 (Boron), with the option of H3.2 CCA.

During the construction phase, moisture stored within porous materials is known as "construction moisture". Residential and commercial projects In New Zealand and Australia typically use few precautions to prevent the materials from getting wet during construction. For mass timber construction, this is not an acceptable situation (refer to *Figure 32* and *Figure 33*).

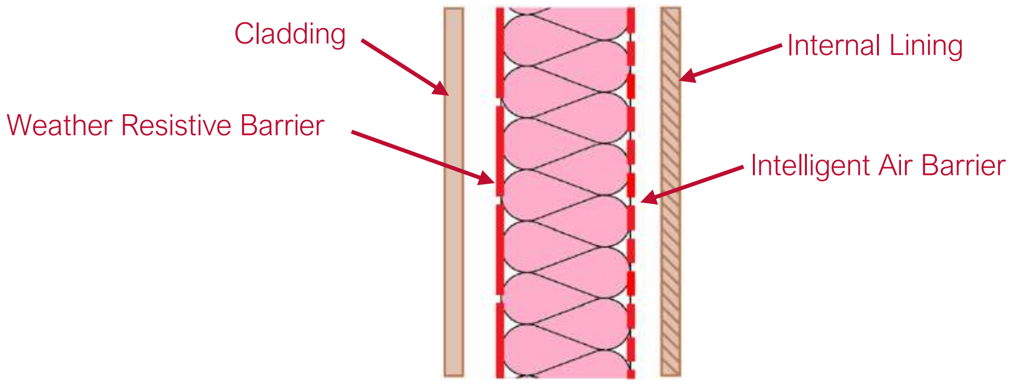


Figure 32: Weather resistant barrier and airtightness seal [4].

19.1 Airtightness

- Prevents heat loss in winter.
- Prevents the entry of hot, humid air in summer.
- Optimises the operation of controlled mechanical ventilation.
- Prevents the uncontrolled passage of warm, moist air and the consequent risk of internal condensation.
- Avoids discomfort due to draughts.
- Improves acoustic comfort.

19.2 Wind Tightness

- Ensures the thermal efficiency of the insulation layer.
- Protects the casing and improves the durability of the materials
- Avoids the formation of currents and convective motions within the casing.
- Serves as a temporary protective layer during construction phases.
- Acts as a temporary protective layer in the event of damage caused by weather events to the roof layer or façade.

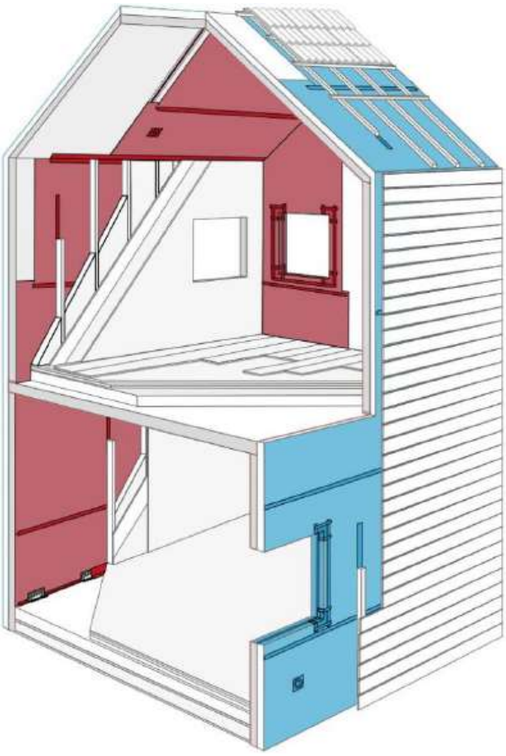


Figure 33: Weather and airtightness [3],[14]

It is essential that wind pressure and rain are managed to prevent them from penetrating the cladding layer into the mass timber elements. The primary weatherproofing objective is to get as close as possible to a perfect airtight and watertight seal.

The objective for the internal building lining is to be as close to airtight as possible to support in controlling the building humidity and energy management (refer to *Figure 34*).

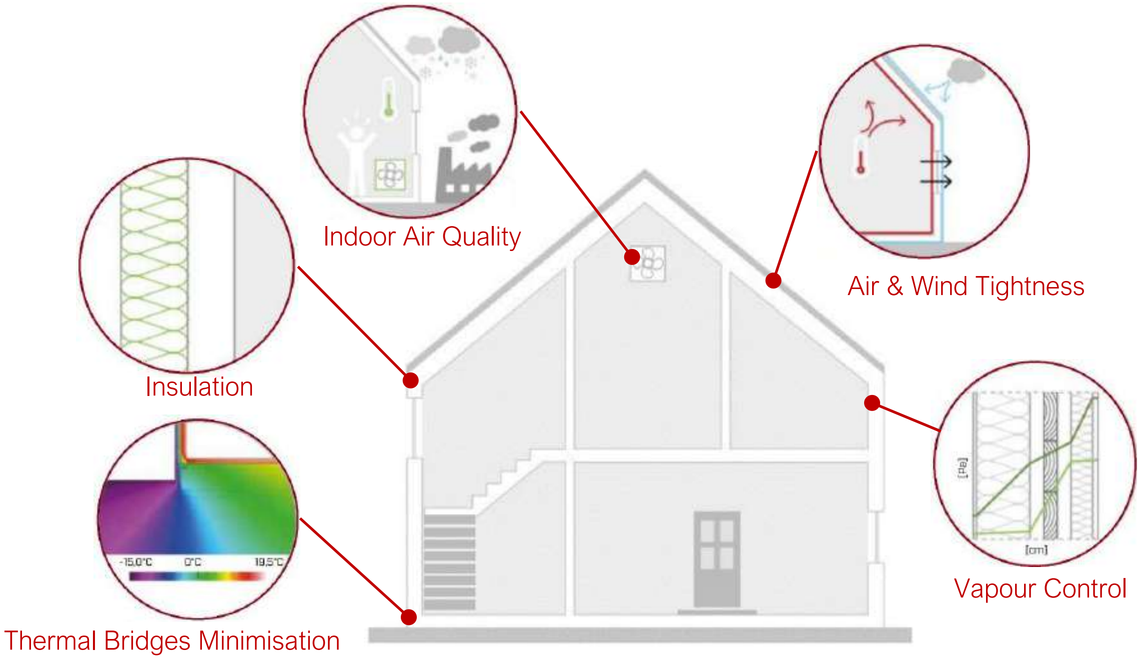


Figure 34: Building envelope performance characteristics [3] [14].

A common trend is to construct mass timber buildings using passive house principles. To achieve increased airtightness, adhesive wrap systems are typically utilised on the wall, roof, and floor elements on either the outside, or both sides of the panels. In the case of membranes applied on the exterior, the airtightness layer needs to overlap and be bonded to all adjacent and interconnecting airtightness layers. Of critical importance is the requirement for full-surface adhesion (in accordance with the manufacturers specification) to ensure that moisture cannot track underneath the membranes.

20. Wall System Moisture Protection

Wall system weathertightness solutions need to ensure that moisture and condensation do not accumulation on timber panels. Specific solutions are based on climate variations, and the associated risk of water ingress due to the rain load and wind conditions. Higher wind zones require better sealed Weather Resistive Barrier (WRB) systems, which in turn result in more airtight buildings (refer to *Figure 35* and *Figure 36*) [5].

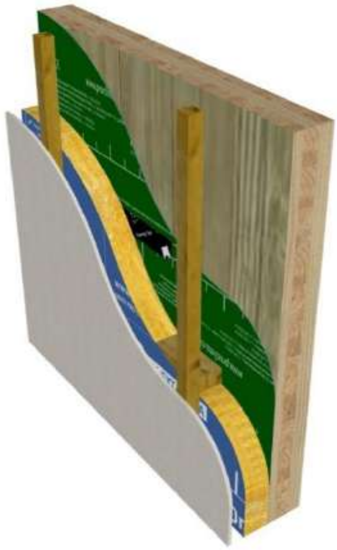


Figure 35: CLT wall build-up with wrap, timber battens, insulation, and cladding/lining [5].

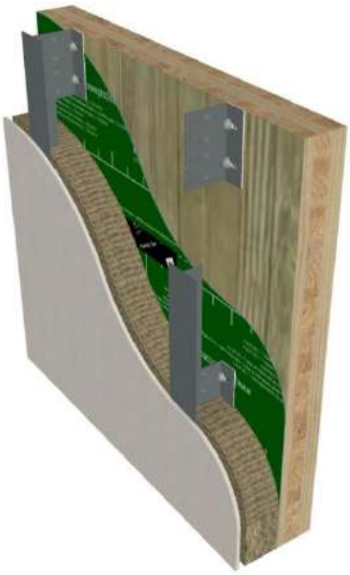


Figure 36: CLT wall build-up with wrap, steel battens, insulation, and cladding/lining [5].

20.1 Moisture Barriers and Connection to the Ground

Moisture barrier connections to the ground are an important and delicate area in timber construction. It is important to design and apply the correct materials and carry-out all workmanship carefully. The proposed European recommendations refer to international standards to promote passive node protection by ensuring the absence of water and moisture at the base of the building (*Figure 37*) [6], [7], [8].

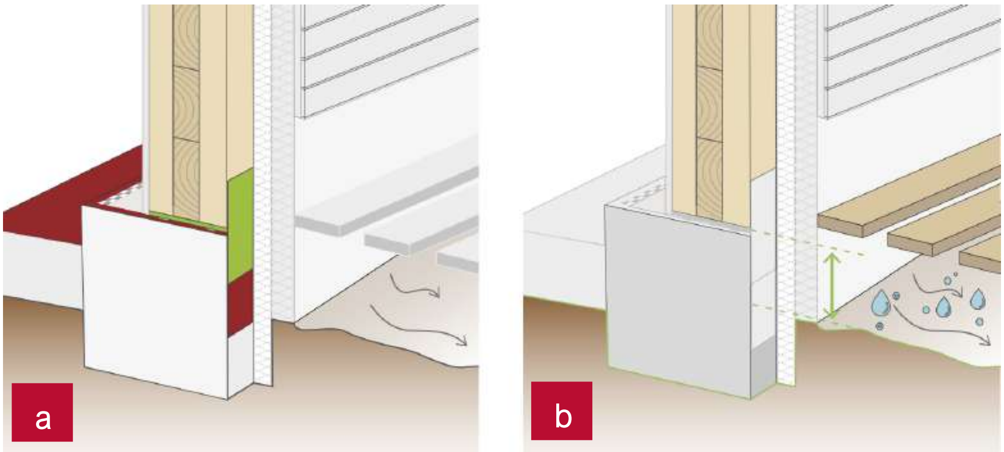


Figure 37: Moisture barrier application; a) No moisture barrier; b) Moisture barrier connections to the ground [14].

Avoid the mass timber structural elements being in contact with soil and ensure that the timber is at a higher level than water drainage plane(s). To prevent the migration of moisture from the concrete to timber walls, use an impermeable barrier between the concrete and the timber structure (*Figure 38*) [3].

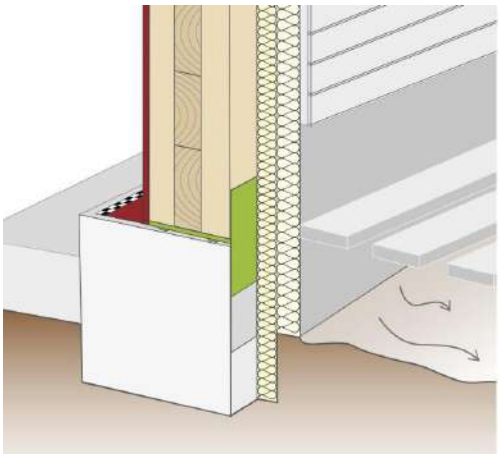


Figure 38: Application of the impermeable barrier between the concrete and the timber structure to prevent the migration of moisture from the concrete to timber wall(s) [14].

One of the coldest points in the building is the connection to the ground or foundation slab, therefore it is important to manage the thermal bridge and ensure air tightness [3].

20.2 Windows and Doors

Window installation in a mass timber building wall assembly must conform to the window manufacturer's instructions. The installation must also consider the adhesive wrap/membrane guidelines to ensure that the fitting of the windows provides watertightness and a moisture mitigation solution. Several window installation techniques are possible depending on the placement of the window frame.

A general cross section of a window installation is provided below in *Figure 39*. A sloped metal sill flashing below the window directs water running off the window to the exterior of the cladding. Below the window, a sloped sill is placed over the CLT rough opening and covered with a self-adhered flashing. A second piece of self-adhered flashing covers laps over both the first flexible flashing and the exterior insulation [9]. Key points to consider when detailing include:

- Air barrier continuity must be maintained from the WRB at the CLT surface, through the rough opening to the window frame [9].
- The membrane used at the windowsill should be resistant to standing water and be vapor impermeable. All other membranes should preferably be vapor permeable to prevent water from being trapped within the CLT panel [9]
- Water should not be drained behind the insulation/WRB interface below a window or other penetration. Water should be drained to the exterior of the insulation or directly to the exterior where possible [9].

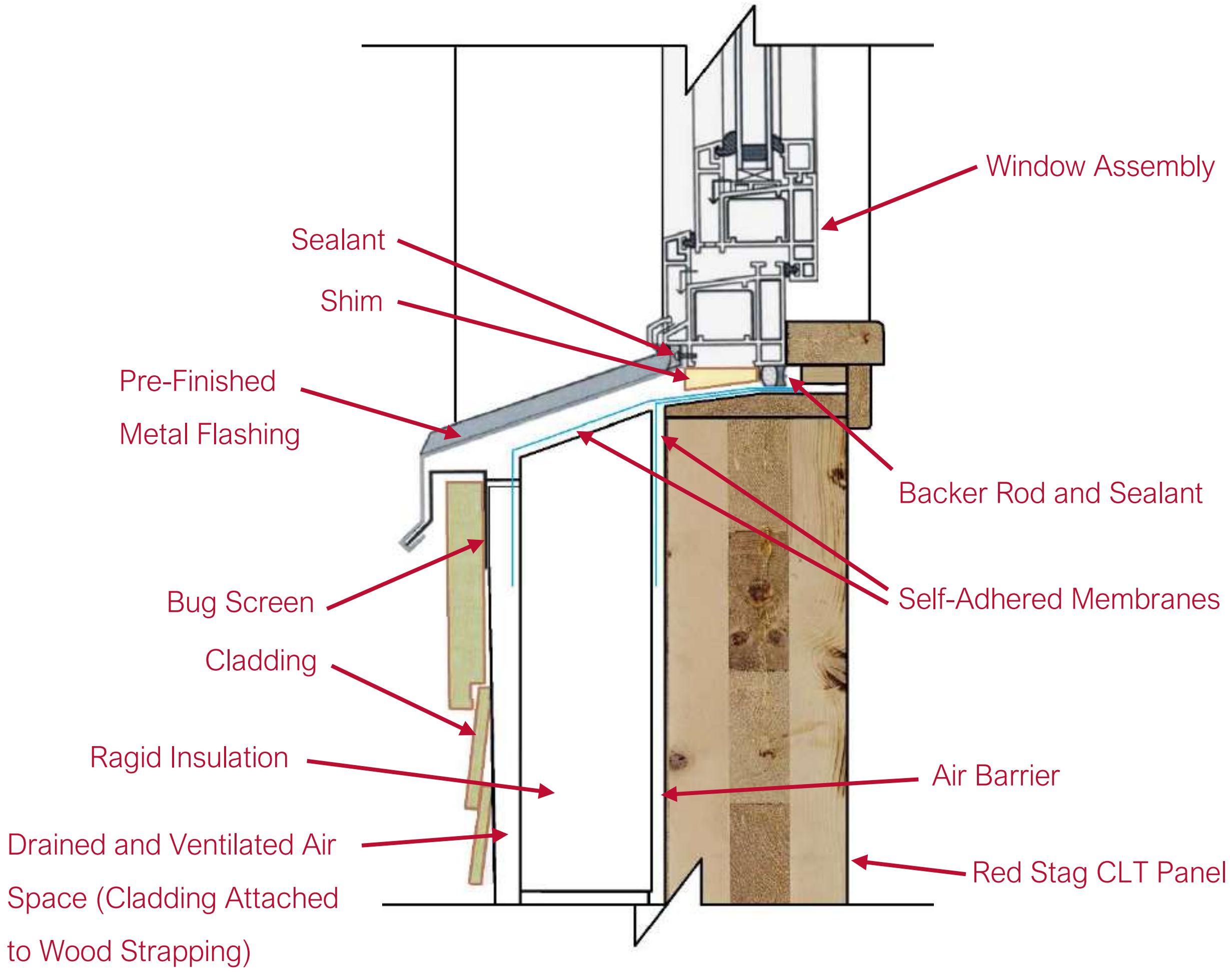


Figure 39: Red Stag CLT wall build-up for window and door openings [9].

20.3 Pre-Applying Wrap to Wall Panels

The application of building wrap in the plant prior to being shipped to site is an optional additional service subject to plant demand and availability (refer to *Figure 40*). The application sequence for wrap applied in factory or on site is as follows [10] [12][13] [14].

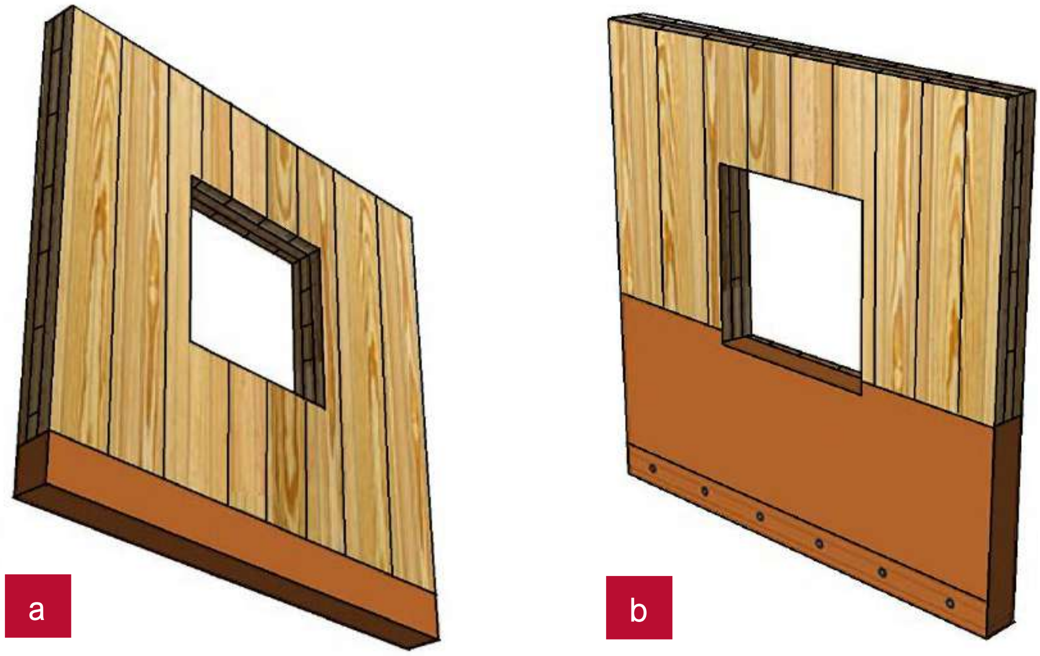


Figure 40: First phase of applying wrap to Red Stag CLT (a) front side, b) back side [10], [13].

1. A strip of wrap is applied to the underside of the panel over its full length to cover the end-grain. The strip should be at least 300 mm up the face of the panel, front and back.
2. The second section of wrap overlaps the base strip. To ensure that a mechanical fixing prevents damage during assembly or in transit, fixing clips can be purchased and applied. The wrap is placed into the window opening in accordance with the window manufacturers recommendations, while ensuring the wrap specifications are maintained (refer to *Figure 41*).

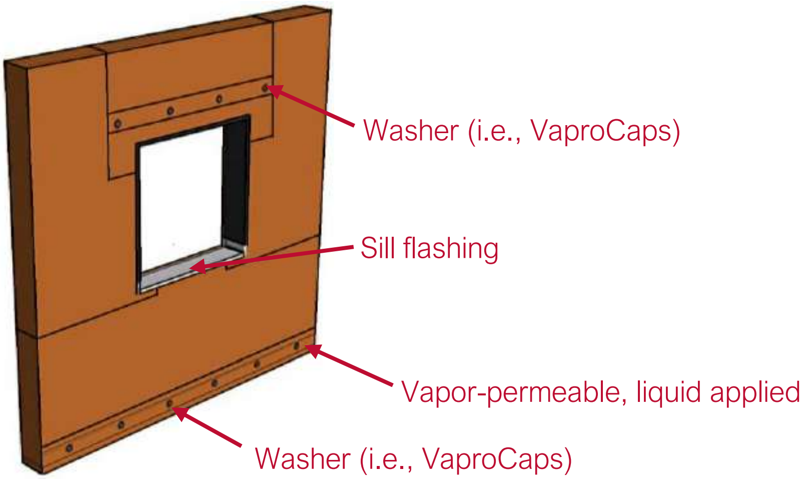


Figure 41: Second phase of applying wrap to Red Stag CLT to prevent damage during assembly or in transit [12], [13].

3. The reaming wall structure, including the header and the sill should then be completely wrapped. Follow the window manufacturing guidelines for window/door applications (on-site or pre-fitted in factory).

21. Green Roof Detailing

Green roofs have become popular in recent years. There are two types of green roofs: ‘extensive green roofs’ with a thin growing medium; and ‘intensive green roofs’, which have deeper soil and are much heavier [11].

21.1 Extensive Green Roofs

Extensive green roofs are shallow and can provide the environmental benefits of a green roof with a growing medium of less than 200 mm, and a roof structure similar to conventional roof coverings. The weight of an extensive green roof is typically between 60 – 200 kg/m^2 and can only support shallow water and root growth, whilst providing some thermal and acoustic insulation benefits.

21.2 Intensive Green Roofs

Intensive green roofs offer larger profiles of up to 1 m deep, allowing them to support larger plants and have a greater water-holding capacity. Intensive green roofs can weigh between 180 – 500 kg/m^2 or more and require a stronger physical roof structure. Intensive options have greater thermal and acoustic insulation benefits but are difficult to retrofit to existing buildings.

The following green roof layering system provides a means of detailing green roofs (refer to *Figure 42*).

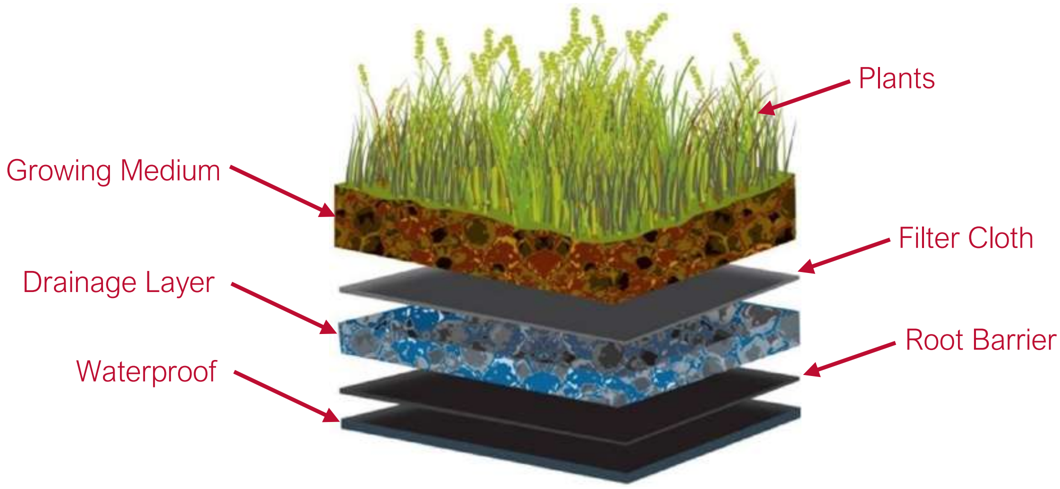


Figure 42: Green Roof Layering Structure [15].

A typical green roof has seven layers on top of the structural components. The first layer is a waterproofing membrane, which is commonly followed by a root barrier layer, optional layer of insulation, drainage layer, filter fabric, growing medium and finally, vegetation. Below the waterproofing membrane is the mass timber superstructure. An engineer will specifically design the roof, based on the type of green roof selected and the weight required to be supported.

21.3 Waterproofing Membrane

There are three major categories of waterproofing membranes: liquid applied membrane treatments, preformed sheets, including ‘single ply’ and integrated systems.

21.4 Root Barrier Layer

The root barrier layer protects the waterproofing membrane. This may not be necessary if a root-resistant waterproofing membrane is selected. Common membranes include polyethylene sheets and polypropylene geotextile fabric. Ensure the root barrier sheet is compatible with the waterproofing membrane to avoid a chemical reaction from occurring.

21.5 Insulation

Green roofs provide significant thermal insulation; however, it may be difficult to obtain accredited insulation so be sure to use conventional means of insulation to meet thermal insulation standards.

21.6 Drainage Layer

A drainage layer carries away excess water and should strike a balance between storing water in the soil and draining storm water.

21.7 Filter Fabric

Laid on top of the drainage layer is a filter fabric made of geotextile materials such as fleece or other woven materials. The layer holds the soil in place and separates the drainage layer from the growing medium, preventing the growing medium from blocking the drainage layer or stormwater system.

21.8 Growing Medium

The growing medium is manufactured soil, crushed brick or other inorganic material which may be supplemented with organic material such as coconut fibre or coir. Using a mixture of native soil and organic or mineral additives can help with water retention, permeability, density, and erosion control. Generally, the growing medium should be 75 - 80 percent inorganic material, such as expanded slate or crushed clay and 20 - 25 percent organic material, such as humus and clean topsoil. This will provide drainage, soil air capacity, and nutrients for the plants.

21.9 Vegetation:

The final layer is the vegetation. Extensive green roofs require low maintenance vegetation and many native plants from coastal and arid inland regions are suitable. Intensive green roof plants can be treated in a similar way to ground level gardens and require the same level of maintenance, but native plants are preferred [11].

The correct use and application of various membranes and barriers is vital to ensuring the enduring performance of a mass timber building. The following figures illustrate a series of application diagrams courtesy of Rothoblaas [3]. Refer to the *Figure* 43 to Figure *46* [14].

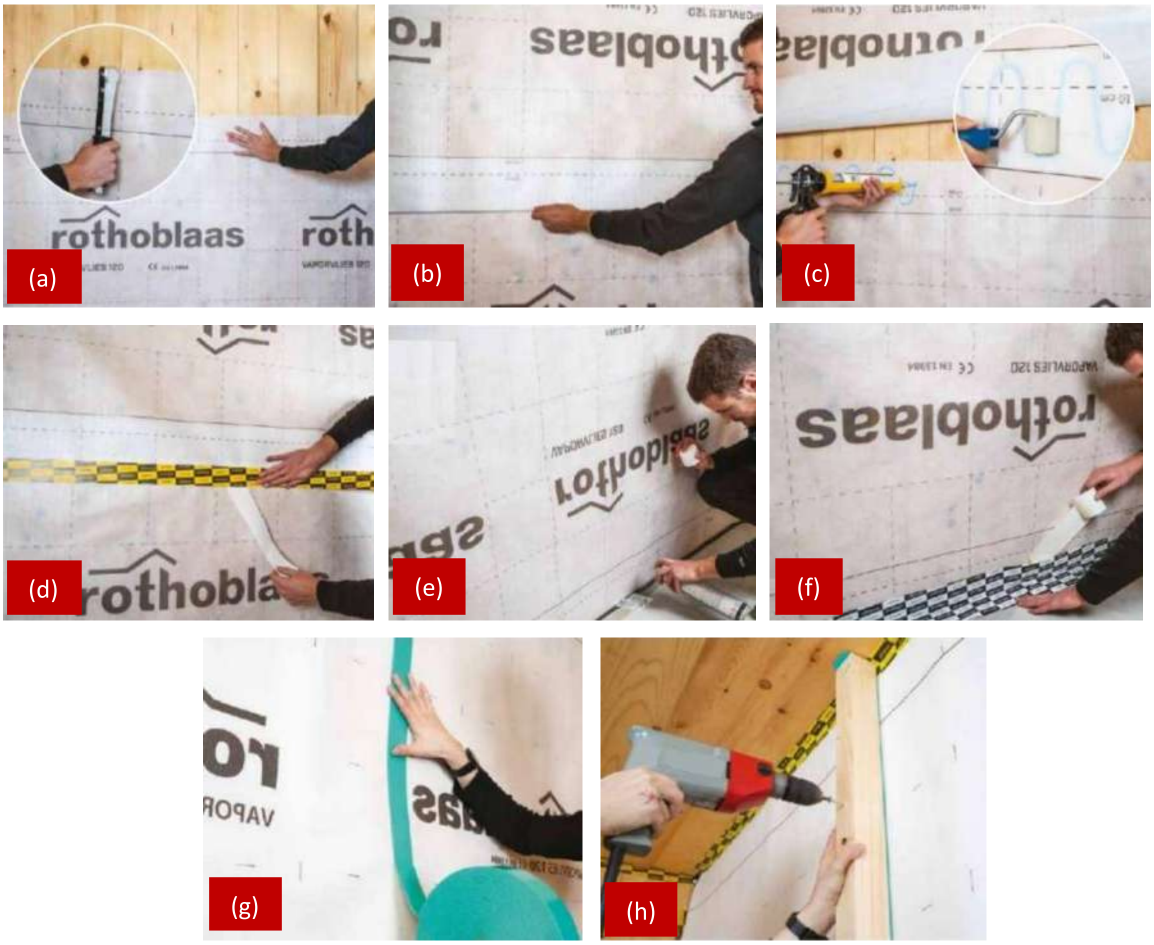


Figure 43: Membrane installation on internal side of a wall [14].

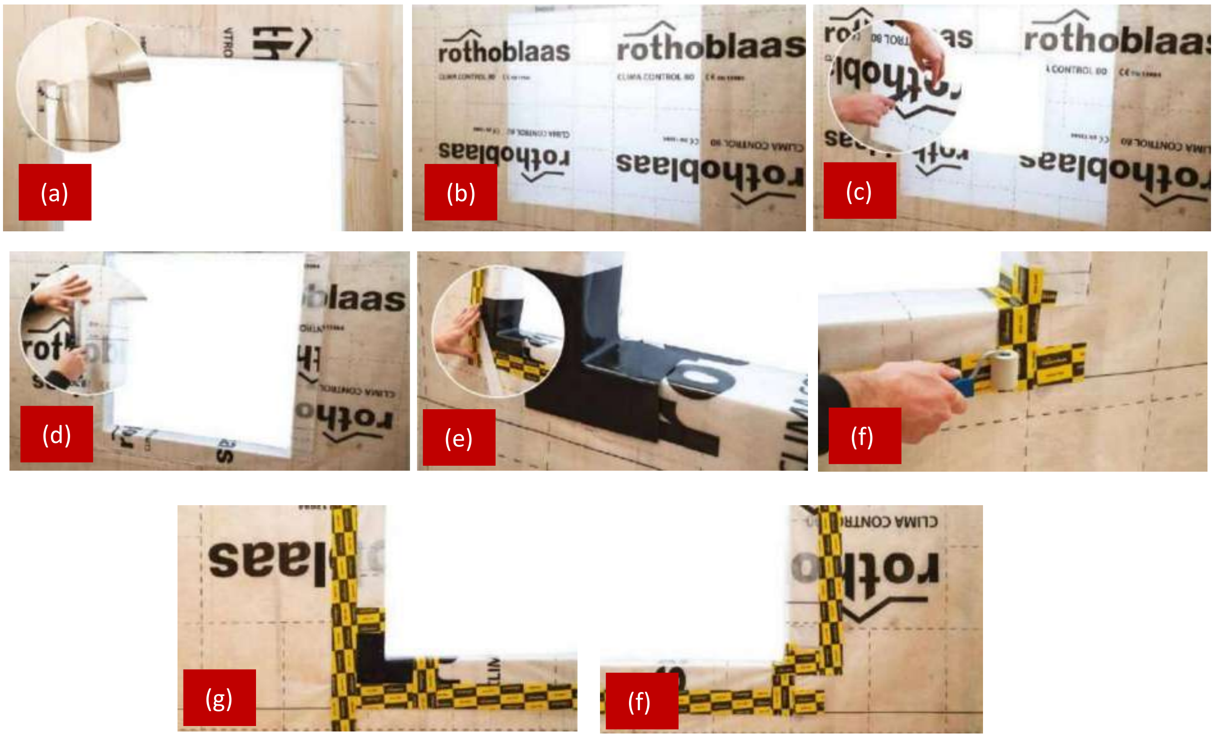


Figure 44: Membrane installation for wall penetrations [14].

Figure 45: Application on internal side of the roof [14].

Figure 46: Membrane installation for roof systems and associated penetrations [14].

Section 4

Red Stag CLT Product Technical Statement

Make it better

Red Stag Project Guide V1.0
August 2022

RED STAG®
WOOD SOLUTIONS

23. Overview

Red Stag is the legal entity within the Red Stag Group focusing on structural EWP, including but not limited to CLT and GLT, Frame and Truss (F&T), advanced stick panelisation and cassette systems. Red Stag has constructed the first phase of New Zealand's largest and most advanced CLT plant (refer to *Figure 47*). The scale facility has the ability to manufacture panels up to 16.5 x 4.5 x 0.42 m (Length × Width ×Depth). *Figure 48* shows panoramic views of the Red Stag EWP manufacturing process in Rotorua.

Figure 47: Red Stag Group of Companies; a) Red Stag primary EWP site in Rotorua, b) Red Stag Timber site in Rotorua, c) Red Stag Frame & Truss manufacturing plant in Hamilton.

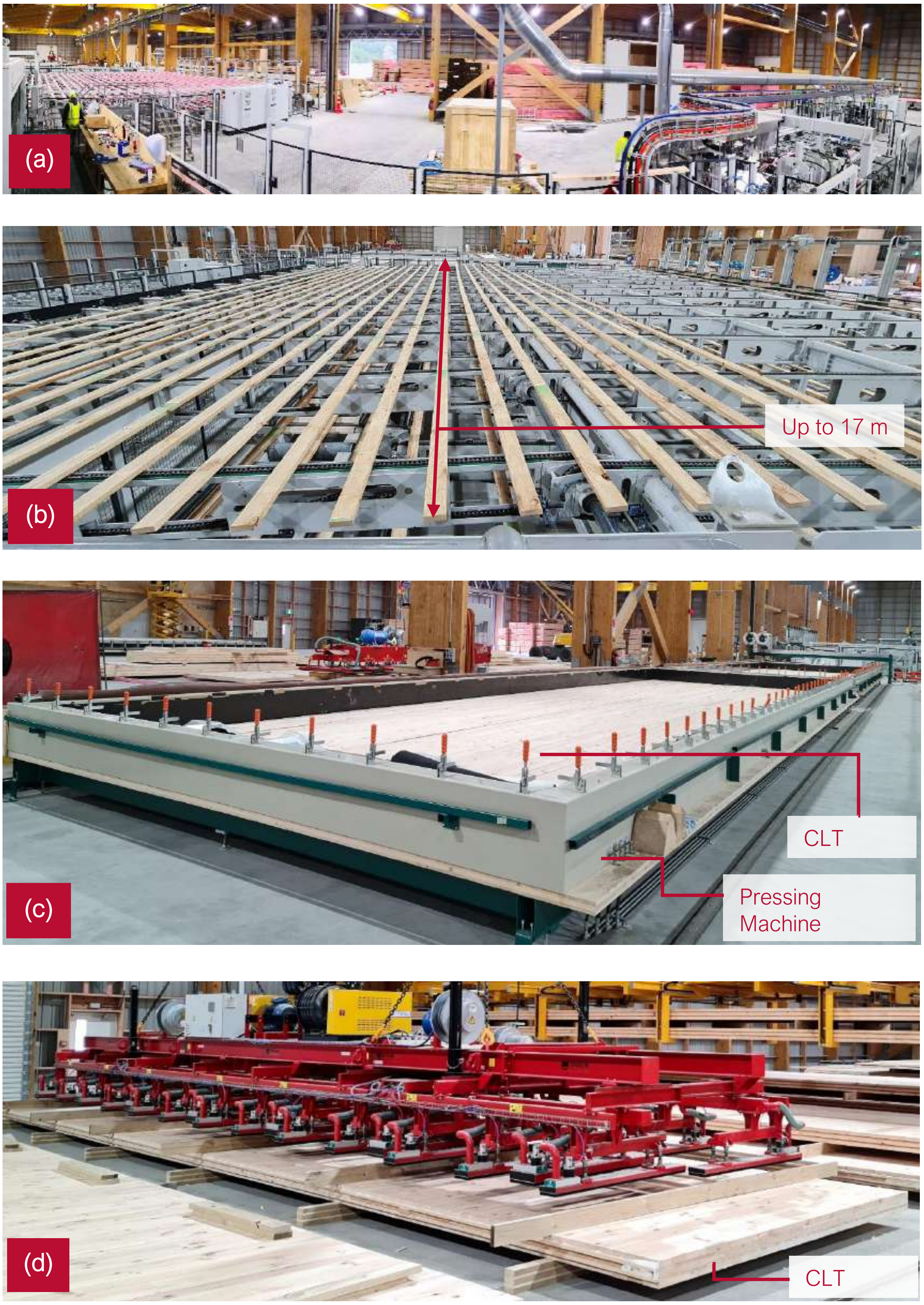


Figure 48: Red Stag's EWP manufacturing facility; a) panoramic view of the Red Stag remanufacturing line; (b) 16.5 meter lamella out of the Finger Joints (FJ) line; (c) EWP laminating equipment; (d) EWP material handling equipment.

24. CLT Purpose and Use

Red Stag CLT is typically used for the primary structural elements in a building, including floor, wall, roof and stair systems. CLT typically outperforms traditional building materials and systems. CLT has very high resilience to gravitational and winds loads, has exceptional seismic resistance, and very high fire performance.

CLT is primarily used for multi-unit construction, including apartments, duplexes, and mid to high rise structures. In lower level residential projects, CLT is commonly utilised for sub floor (generally due to ground conditions and topology), mid floors and stairs. Similar to residential, commercial applications typically focus on floors, stair wells, lift shafts, stairs and internal load bearing walls. External CLT walls are generally used in applications where there are larger gravitational loads, balloon wall systems are required and/or the building needs to be erected and enclosed quickly.

Red Stag CLT panels are suitable for a wide range of load conditions and wind zones based on AS/NZS 1170.1:2002 (Structural design actions - Part 1: Permanent, imposed, and other actions), AS/NZS 1170.2:2021 (Structural design actions, Part 2: Wind actions) and NZS 3603:1993 (Timber Structures Standard is currently under review with an anticipated 2022 revision).

Globally CLT is being used as the primary structural element for buildings in excess for 20 stories or +100 m meters in height. This includes areas with high seismic conditions similar to New Zealand (refer to *Table 5*).

Table 5: Scope and limitations of use [a]

Location	Limitation
In any wind design Ultimate Limit State (ULS).	The design and specification of Red Stag® CLT is subject to specific engineering design.
In any exposure zone as defined in NZS 3604:2011.	Where microclimatic conditions apply as set out in paragraph 4.2.4 of NZS 3604:2011, contact Red Stag® Wood Solutions Limited for advice.
In all seismic zones.	
In all snow loading zones.	
Any proximity to a relevant or notional boundary	Where located within 1 m of a relevant or notional boundary the specification of Red Stag® CLT is subject to specific fire engineering.
[a] Red Stag Pass Document (Product Assurance Supplier Statement). Refer to *Appendix D*.	

24.1 CLT Floor Systems

CLT floors are a direct substitute for traditional joisted floor systems, substituting structural timber, Laminated Veneer Lumber (LVL), timber I beams, and sheet flooring. Similarly, CLT can substitute concrete and concrete/steel hybrid solutions. Advantages of CLT: Can be designed to transfer load along and across the span(s), is lighter, and significantly faster to install.

24.2 CLT Wall Systems

CLT wall applications allow for the substitution of light timber and steel framing and can also substitute precast, insitu poured, and concrete block options subject to the design requirements. CLT walls include significant bracing properties, typically removing the need for secondary cross or sheet bracing.

CLT walls have a high fire rating, supporting the use for balloon wall systems, for exterior applications, stair wells and lift shafts. Red Stag ballooned CLT walls can be designed up to 16.9 m in height and up to 4.9 m wide if required.

24.3 CLT Roof Systems

Similar to floors, CLT roof systems can substitute traditional rafter systems, and can be designed to act in both directions (in both the direction of span and across the span). CLT roof systems expedite the time to enclose the building envelope, reducing the risk of moisture ingress and expedite internal trades.

24.4 CLT Stair Systems

CLT stairs provide a very strong, light, aesthetically pleasing alternate to insitu poured and precast concrete stairs. CLT stairs are typically designed to be self-supporting and can be designed to carry construction loads. CLT stairs are faster to install and remove the need for temporary stairs and ladders on site.

Red Stag has developed a PASS™ compliance document to confirm that Red Stag CLT conforms as an Alternate Solution with the New Zealand Building Code (refer to the Red Stag PASS document: https://www.thebuildingbusiness.co.nz/pass/red-stag-pass-landing). The PASS document is supported by the Red Stag's Quality Assurance (QA) programme (refer to *Appendix D* of *Red Stag Project Guide* and *Section 7* of the *Red Stag CLT Design Guide*) and third party verified test evidence presented in *Schedule 1 to 3* (refer to *Section 4.35* of *Red Stag Project Guide*). Internal QA and test evidence confirms that all details outlined in the PASS document and associated Red Stag Design and Project Guides are repeatable and fit for purpose.

To simplify the compliance pathway, Red Stag has engaged with Bureau Veritas as its third-party auditor and CodeMark certifier[iii].

[iii] Red Stag is working through the CodeMark process with Bureau Veritas. The process is expected to be finalised by 31 October 2022.

26. CLT Performance Claims

If designed, installed and maintained in accordance with all Red Stag® Wood Solutions Limited requirements, Red Stag® CLT will comply with or contribute to compliance with the following performance claims (refer to *Table 6*):

Table 6: CLT Performance Claims [a]

NZ Building Code Clauses	Basis of Compliance	
	Compliance Statement	**Demonstrated by**
B1 STRUCTURE B1.3.1 B1.3.2 B1.3.3 (a, b, c, f, I, j, m, q) B1.3.4 (a, b, d, e)	Verification method B1/VM1	Tested for bending strength to AS/NZS 4063:2010 and EN 16351:2015 (E). [Scion[22], 27/06/2019]. Red Stag verification testing [November 2021].
B2 DURABILITY B2.3.1 (a) B2.3.2 (a)	ACCEPTABLE SOLUTION B2/AS1	Feedstock treated to NZS 3640:2003. Audited and tested in accordance with IVS Treatment Assurance Programme [IVS, 24/06/2021; 29/11/2021, 08/12/2021].
C6 STRUCTURAL STABILITY C6.2 C6.3	VERIFICATION METHOD	Expert assessment of expected structural fire capacity of Red Stag® CLT floors [Enovate, 29/07/2021; 20/08/2021; Warrington Fire, 03/08/2021].
F2 HAZARDOUS BUILDING MATERIALS F2.3.1	ALTERNATIVE SOLUTION	Application of NZTPC Best Practice Guideline for the Safe Use of Timber Preservatives & Anti-Sapstain Chemicals. Red Stag® Timber Ltd is part of the IVS Treatment Assurance Programme [IVS, 24/06/2021; 29/11/2021, 08/12/2021]. Use in accordance with manufacturer's safety requirements.

[a] Red Stag PASS Document (Product Assurance Supplier Statement).

27. Designing with CLT

Red Stag has established a comprehensive design guide (*Red Stag Design Guide*) to support architects, engineers, and specifiers in understanding how to incorporate Red Stag CLT into projects. The design guide incorporates all CLT properties, performance characteristics (structural, fire, acoustic, thermal, etc), and supporting design calculations. Please refer to the Red Stag CLT Design Guide for more detail.

Supporting the *Red Stag Design Guide* is the *Red Stag Project Guide*. The project guide details all shop drawing processes, lifting solutions, building envelope management, panel assembly and site guide, durability, and warranty statements, etc.

28.1 Red Stag's CLT Fabrication Process

All Red Stag EWP timber feedstock is supplied from Red Stag Timber (RST) (*Figure 46 a*). RST has that most modern structural sawmill in New Zealand and carefully selects the highest density logs and processing methodologies to grade and process timber for structural applications (refer to *Figure 49*).

Figure 49: RST remanufacturing line.

Feedstock allocated for EWP is typically pre-graded sonically by RST into five Modulus of Elasticity (MoE) grades: sub 6 GPa; 6 GPa (6.0 – 7.9 GPa); 8 GPa (8.0 – 9.9 GPa); 10 GPa (10.0 – 11.9 GPa); 12 GPa (≥ 12 GPa). Each grade is tail flashed (automatically painted by the acoustic grading system with a unique colour per grade) through the process and collects each grade in separate bins for packetising (refer to *Figure 50*).

Once graded, the packets are then sent to RST's timber treatment plant for treatment. Based on the grade requirements, this is either H1.2 (Boron; typically clear boron) or H3.2 (Copper Chromium Arsenic (CCA)).

Post-treatment, the timber is re-dried in kilns to bring down to a targeted Moisture Content (MC) of 14 percent (± 2 percent). After the re-drying process, the timber is regraded to confirm that the moisture content is within the required range and the MoE is re-confirmed. The moisture content is not critical for the adhesive process, as PUR adhesive reacts with moisture. Based on the moisture content at the time of gluing, the misting function press glue application system will either be turned on or off (off if the moisture content is above 12 percent).

Figure 50: Red Stag's feedstock storage prior to the remanufacturing process.

28.2 Planing

Red Stag has latest version of the Weinig PowerMat 2500 planer, specifically selected for the extremely tight tolerances required for precision EWP planing accuracy. The PowerMat follows an automated defecting, FJ, and curing line.

The PowerMat planer allows for a tight uniform tolerance to target a finish within ± 0.1 mm with pitch marks targeted at 2.0 mm ± 1.0 mm.

28.3 Adhesive

Red Stag is utilising Henkel PURBOND PUR adhesive in its EWP process to create structural grade FJ and face bonds between EWP layers (Note: Red Stag is not edge gluing its EWP).

Henkel Purbond PUR has an open to close time ration of 1:2.5 at 20 degrees Celsius (°C). A commonly used PUR is HBS309 with an open time of 30 minutes, requiring a close time under pressure of 75 minutes at 25 degrees Celsius (°C). The Henkel open time to close time curves are temperature dependent, as illustrated in *Figure 51*.

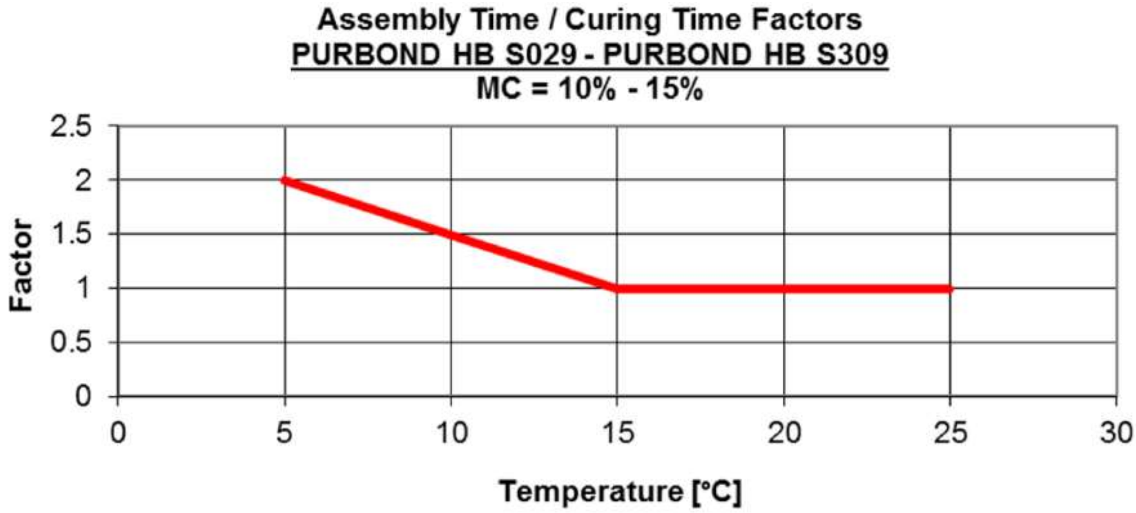


Figure 51: Henkel PURBOND Temperature Dependent Close Time Factor Graph [16].

Although the Henkel data in *Figure 51* only goes down to 5 °C, Henkel has confirmed that their Purbond adhesives will perform structurally as long as the timber substrate temperature is no less than 1 °C. The data in *Figure 51* is limited to a MC range between 10 – 15%. As PUR is reactive with moisture, the higher the moisture content, the faster the adhesive reaction rate. Henkel has standard data for MC up to 18%, but have test data to confirm the bond strength on FJ on timber up to 55% MC.

Red Stag is targeting to produce EWP lamellas with a MC range between 12 – 16 percent to maintain the stability of the processed EWP members. Performance data shows that the bond strength of EWP elements with a surface moisture contents as high as 35 percent does not adversely impact the EWP element and associated bond strength.

28.4 Moisture Content Measurement

Red Stag measure the moisture content of the feedstock prior to the remanufacturing process (grading, defecting, FJ, curing, and planing) using suitable timber moisture measuring device (e.g. T510) (refer to *Figure 52*)[iv].

Figure 52: Moister content measurement of the EWP lamella with suitable timber moisture meters (resistive meters illustrated, but capacitance meters are also acceptable).

The correlation table for moisture correction based on meter readings due to boron (H1.2) treatment is detailed in *Table 7*.

Table 7: Moisture reading correction table [a].

METER READS	TRUE MC Boron H1.2	TRUE MC LOSP H3.1	TRUE MC CCA H3.2
10	11	13	10
11	11	14	11
12	12	15	12
13	12	16	12
14	13	17	13
15	13	18	14
16	14	19	14
17	15	20	15
18	16	21	16
19	16	22	17
20	17	23	18
21	18	24	19
22	19	25	19
23	20	26	20
24	21	28	21

[a] https://www.redstagtimber.co.nz/products/new- zealand-products/technical-information/moisture-content/

Based on *Table 7*, the readings in *Figure 51* reduce the meter reading of 20 percent moisture down to an actual moisture reading of 17 percent.

[iv] Please note that due to the higher electrical conductivity in the boron salts in the treatment process, the moisture level reads higher on the meter than the true moisture level in the timber. This is amplified when using uninsulated probes in the resistive moisture meter or capacitance type meters.

28.5 Gluing and Pressing

To ensure the quality and integrity of the glue line bond, planing is managed wherever practically possible to be within 24 hours, but ideally no more than 48 hours.

Red Stag has Fankhauser CLT vacuum presses from Switzerland and associated glue gantry system. The glue gantry has onboard glue storage, PLC controlled glue application gear pump, independently actuated glue ejector nozzles and laser alignment system. This configuration allows for the operator to set the required glue application rate, ejector position and overall glue blanket width for each pass from the onboard glue gantry control system.

Although the onboard PLC controls the flow rates for the adhesive, the operator must still test and confirm/make minor adjustments to the distribution rate by pre-weighing A3 test paper sheets, applying adhesive and post weighing to ensure that the glue application is within 160 to 170 g/m^2 +/- 5 g/m^2.

The glue application rate is finalised after the first layer of lamellas is laid up in the press, but before any glue is laid onto the timber (process completed over the first layer of timber onto disposable paper). Refer to *Figure 53*.

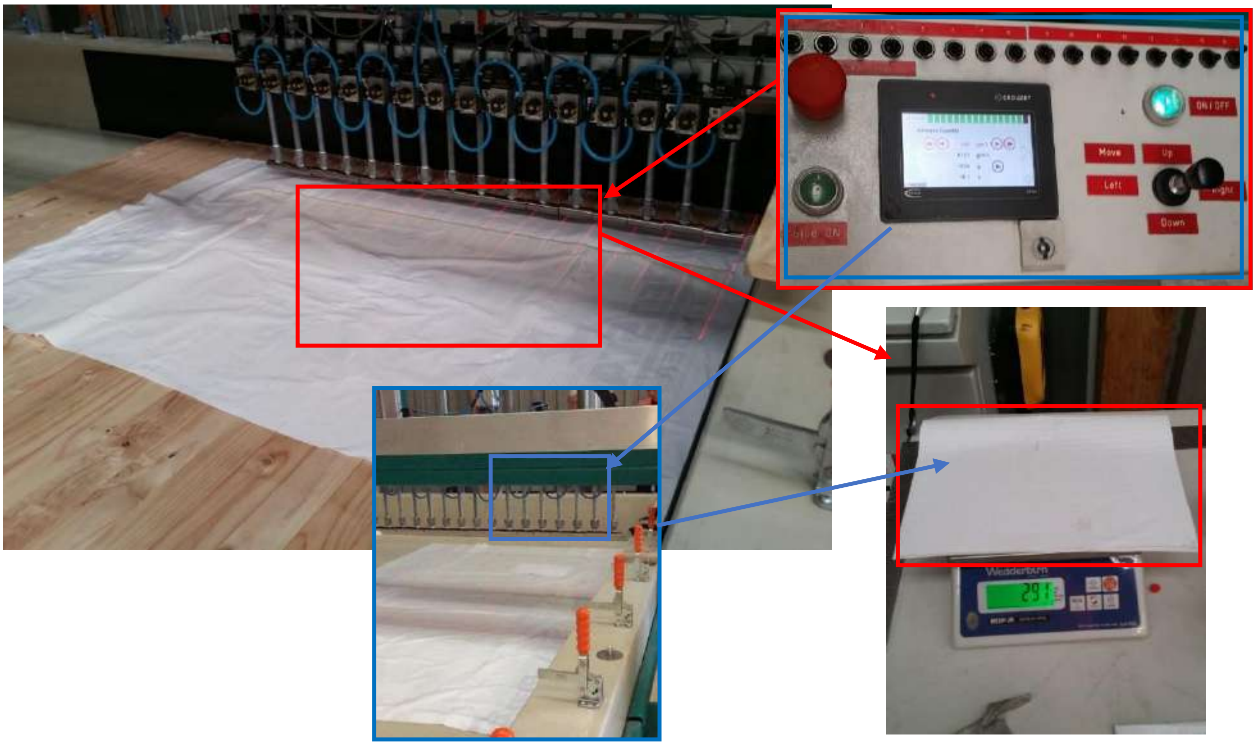


Figure 53: Laminating glue application rate QA management (g/m^2).

When a timber layer is ready for gluing, the operator starts the open time counter by logging the time and then utilises the glue gantry to apply uniform layers of PUR across the entire timber layer's surface (refer to *Figure 54a* and *Figure 54b*). Where necessary, the operators use a notched trowel to spread the PUR evenly at each end.

Following each glue layer, operators apply the next layer of timber in the opposing direction and repeat the gluing process until the entire billet recipe is completed.

Once all layers have been laid up, the operators apply slight longitudinal and lateral pressure using the build in hydraulic compression system to reduce the gaps between both the longitudinal and transverse boards. Refer to *Figure 54e*.

The vacuum membrane is then pulled over the billet, clamped down, and the vacuum pump is started to evacuate gas from the vacuum press chamber (from within the cavity generated between the press liner, CLT billet and membrane). When the system gets down to approximately 800 mBar (~8.1 MT/m^2), the operator must log the time and confirm that the open time is within the specification of the glue, based on the atmospheric conditions (e.g., at 20 °C, HBS309 is 30 minutes, but at lower temperatures, is longer – refer to Henkel data sheets). Refer to *Figure 54e*.

When the vacuum pressure drops down to approximately 900mbar, the operator reduces the pressure on the hydraulic cylinders to allow the membrane to pull down the timber surfaces flat, to reduce any lipping between lamellas.

The system must remain under vacuum, for the full close time. This is determined by the PUR supplier's specification based on the adhesive grade and atmospheric conditions. The operator should add the open time from when the first adhesive was applied to the required close time and ensure that the system remains under the required vacuum for the full duration (if the operator(s) have the system under vacuum ahead of the allowable open time, the difference between the actual close time and the allowable open time must be added to the close time to ensure that the system is under vacuum at the required pressure for the required period).


(a)


(b)


(c)

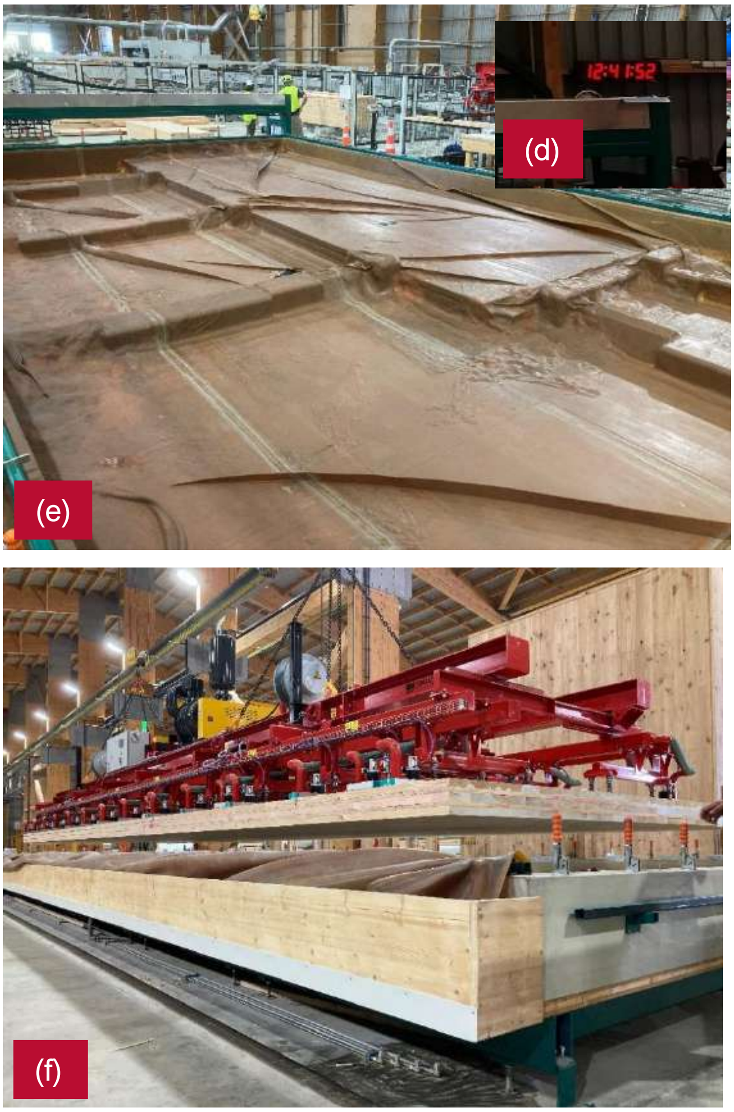


Figure 54: (a) Red Stag CLT gluing process; (b) Gluing laser alignment system; (c) Short lamella layup; (d) Clock/timer to log open and close times; (e) Panel under vacuum; (f) Cured laminated EWP billet being removed from press.

Once the system has been maintained under vacuum for no less than 2.5 times the open time (actual closed time is based on the glue type being used, timber moisture content and the atmospheric conditions), the operator can turn off the vacuum pump to the press, break the vacuum and remove the membrane. The billet can then be inspected to ensure everything appears in order and can then be removed to allow for the process to repeat for additional production.

29. EWP Quality Assurance Programs

Red Stag has an extensive QA programme, supported by internal Standard Operating Procedures (SOP), production management processes, and training documentation. QA is managed through the process billet by billet to ensure that every parent element (billet) properties are tightly managed to ensure that they adhere to the defined design properties. QA processes include sign off by each team in the process and have a summary sign off to ensure that every step has been accurately controlled and measured in line with the specifications and associated SOP. QA processes managed through the process include, but are not limited to:

1. Feedstock conformance to the specification (MoE and treatment).
2. Finger Jointed structural performance.
3. Lamination performance (delamination or shear block testing).
4. Billet dimensions and properties.
5. Panel dimensions and properties.
6. Transportation bundling alignment to the schedule.

Red Stag has engaged with Bureau Veritas as its QA and auditing partner. Bureau Veritas is also supporting Red Stag with establishing a CodeMark for all of its EWP.

30. Supporting Schedules

In addition to this Product Technical (PTS) Statement, three supporting schedules have been attached to act as supplementary supporting evidence to confirm Red Stag manufacturing processes produce fit for purpose EWP elements.

Schedule 1: Summarises the CLT design calculations based on the FP Innovation CLT design guide to show that the recommended recipes for CLT panels perform structurally under applied service loads based on the New Zealand building standard for floor applications in residential and commercial projects (refer to *Section 4.35.1*).

Schedule 2: Presents the Red Stag EWP manufacturing procedures, the experimental mechanical test results, and an experimentally verified numerical model to predict the behaviour of Red Stag EWP panels for floor applications. Testing confirms Red Stag CLT panels perform in excess of the New Zealand building design standard (refer to *Section 4.35.2*).

Schedule 3: Details a large scale loaded fire test performed by Red Stag based on the AS 1530.4:2014 standard to investigate the fire resistance of CLT floors. Testing proved that Red Stag CLT performs in excess of the New Zealand building design standard. Fire test results and associated third party fire reports confirm that Red Stag CLT maintains its structural performance for over 60 minutes (refer to *Section 4.35.3*).

31. Assembly and Site Management

Red Stag has developed a comprehensive project guide (*Red Stag Project Guide*) detailing all processes from shop drawing, project coordination for manufacturing, delivery and assembly. Within the project guide are sections on lifting, panel assembly and site guide, etc.

Installing CLT is a relatively straight forward process; however, the project guide provides details on many aspects that will simplify the process for the installer, ensuring assembly is managed safely and compliant with the requirements of the project.

Traditional qualified builders and carpenters should be more than capable of installing and assembling CLT structures with the support of suitably experienced riggers and crane operator(s). Installers should refer to the *Red Stag Project Guide* and coordinate with the project engineer to ensure that all elements are installed, propped (as required) and fixed using the specified fixings, and that all fixings are located correctly and installed in line with the engineering specifications.

32. Maintenance

Red Stag CLT is full treated; however, as it is an organic material, care and attention needs to be taken to prevent moisture ingress. To support the management of moisture within the CLT and building envelope, please refer to the *Red Stag Building Envelope Guide* (*Section 3*) and the *Red Stag Panel Assembly and Site Guides* (*Section 5*).

33. Durability

Red Stag's durability statement covers Red Stag CLT and GLT installed in the following locations as defined in NZS 3602:2003 Table 1A as updated by the New Zealand Building Code (NZBC) B2/AS1 amendment 10 to meet a 50 year durability performance:

- Where not exposed to weather or ground atmosphere, but with a risk of moisture penetration conducive to decay (Ref 1D14, exterior walls).
- Where not exposed to weather or ground atmosphere and in dry conditions (Ref 1E2 mid-floors and ceilings, 1E5 internal walls, 1E7 interior flooring).

Please refer to the *Red Stag Durability Statement* (*Section 7*) for more details.

34. Warranty

Unless otherwise specified in the Quotation, Red Stag warrants its CLT against faulty materials or workmanship for a period of 12 months from the earlier of either the original scheduled delivery date or the date of delivery of the Products to the Customer. Please refer to the Red Stag Warranty Statement for more detail.

35.1 Schedule 1: CLT Floor Panel Design

35.1.1 CLT Floor Panel Design for Residential, Commercial and Industrial Buildings

Table 8 summarised the design calculations for loaded 126 mm thick Red Stag CLT floor panels (*Figure 55* and *Figure 56*) for residential, commercial, and industrial building applications based on the FPInnovation CLT design guide.

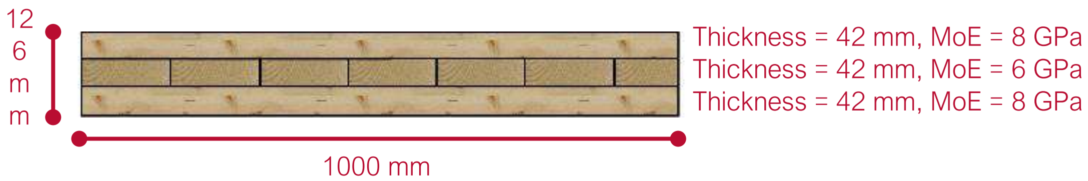


Figure 55: Red Stag CLT Panel Cross-Section.

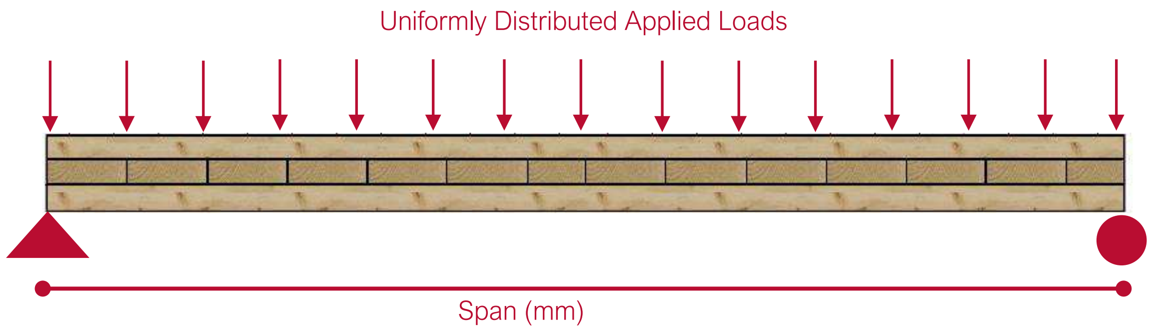


Figure 56: Red Stag CLT Panel Elevation.

Table 8: 126 mm thick CLT floor panel design calculation results [a, b, c, d, e].

	Applied Loads (kPa)								
	Dead Load = 0.5 kPa			Dead Load = 1.0 kPa			Dead Load =1.5 kPa		
	Live Load (Imposed Load)			Live Load (Imposed Load)			Live Load (Imposed Load)		
	2 kPa	3 kPa	5 kPa	2 kPa	3 kPa	5 kPa	2 kPa	3 kPa	5 kPa
Span	4.09 m	3.83 m	3.45 m	3.77 m	3.57 m	3.26 m	3.53 m	3.37 m	3.11 m
Deflection from Calculation (mm)	10.17	9.54	8.62	9.37	8.87	8.09	8.80	8.40	7.73
Deflection from AS/NZS 1170 (mm)	10.22	10.22	8.62	9.42	8.92	8.15	8.82	8.42	7.77
Deflection. from Calculation / Deflection. from AS/NZS 1170	0.99 Passed	0.95 Passed	0.99 Passed	0.99 Passed	0.99 Passed	0.99 Passed	0.99 Passed	0.99 Passed	0.99 Passed
Moment Capacity from Calculation (kN.m)	33.01	32.54	31.69	32.42	31.98	31.18	31.89	31.48	30.72
Applied Moment from AS/NZS 1170 (kN.m)	9.22	10.84	13.26	8.90	10.37	12.63	8.74	10.09	12.22
Moment from Calculation / Moment from AS/NZS 1170	0.28 Passed	0.33 Passed	0.41 Passed	0.27 Passed	0.33 Passed	0.40 Passed	0.27 Passed	0.32 Passed	0.39 Passed
Vibration Performance	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed

[a] Strength Reduction Factor (Ø) = 0.9 [17].

[b] Bending Strength (Fb) = 14 MPa [17].

[c] Red Stag CLT density of 500 kg/m^3.

[d] Red Stag Five Layer CLT Weight = 0.675.

[e] Further calculation details are provided in the Red Stag CLT Design Guide.

35.2 Schedule 2: CLT Fabrication Processes, Experimental Test, and Numerical Model

Three essential steps in ensuring the integrity and design performance of manufactured CLT panels are: delamination testing to determine the glue bond performance, four-point bending tests to determine the strength and stiffness, and numerical modelling.

35.2.1 Glue Bond Performance Testing

The moisture content of the lamella (timber boards) used in EWP production is one of the factors that has been considered by Red Stag to determine the impact of the adhesive bonds. Henkel or Red Stag (via a heavily automated laboratory with state-of-the-art testing equipment from Europe) determine the performance of the glue line bonds via regular testing. Examples of nine test samples used to determine the lamination performance are summarised in *Table 9*. The results show an average delamination percentage of 4.39 percent, which is under the five percent standard limitation to ensure sufficiently durable glue line bonds. The surfaces where minor delamination was observed is highlighted in *Figure 57*.

Each sample has four faces, equating to thirty-six faces in total for the nine samples. The 28 faces not illustrated in *Figure 57* had no (zero percent) observed delamination.

In addition to the delamination testing, nine large scale bending experimental tests conducted by SCION[v] proved no adverse glue line performance issues (results reasonably exceeded all performance criteria). No glue line failure or board separation was observed during all large-scale deflection testing conducted by SCION (Testing was to destruction. Rolling shear and tension rupture eventually caused the failures. Refer to *Figure 58*). Further information related to the large scale bending tests is documented below.

[v] SCION is a New Zealand Crown research institute that specialises in research, science and technology development for the forestry, wood product, wood-derived materials, and other biomaterial sectors.

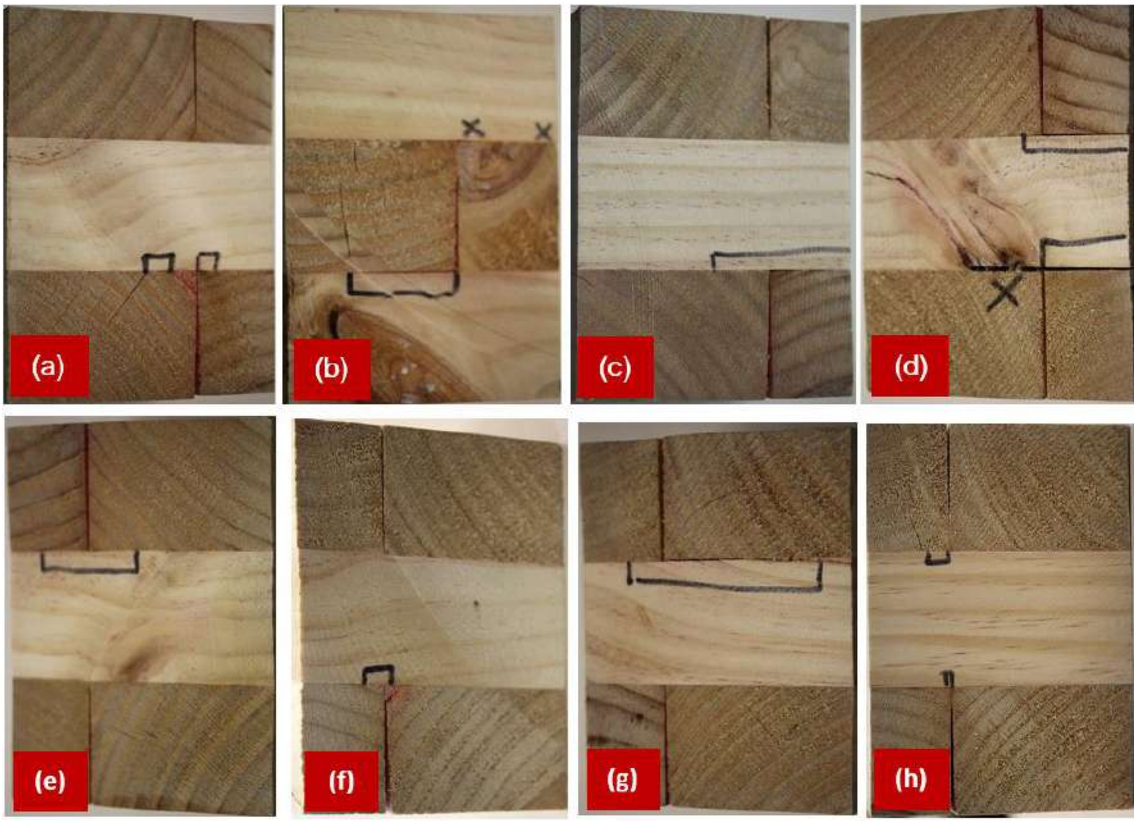


Figure 57: Marked/highlighted sections are the only areas where minor delamination occurred.

Table 9: Delamination test results for the nine test samples associated with the bending test specimens.

Sample Number	Mass (original)	Mass (saturated)	Mass (redried)	Width (mm)	Layers Bounds	Delam (mm) Face	Delam (mm) Back	Percent Delamination
1	627.3	1418.5	632.5	100	4	0	8	1.00%
2	587.3	962.1	592.1	100	4	0	0	0.00%
3	603.4	1205.2	627.8	100	4	70	37	13.38%
4	595.3	1188.9	601.9	100	4	0	0	0.00%
5	638.9	1331.7	668.9	100	4	10	18	3.50%
6	664.3	1401.1	693.9	100	4	0	0	0.00%
7	641.3	1174.1	681.4	100	4	39	0	4.88%
8	632.1	1363.6	655.8	100	4	0	0	0.00%
9	673.2	1449.3	697.1	100	4	52	80	16.50%
Average delamination for nine test samples								4.36 %

Figure 58: Failures in large scale CLT bending tests; (a) Rolling shear failure; (b) Tension failure.

35.2.2 Large Scale Red Stag CLT Experimental Testing

Nine large scale four point bending tests were conducted based on EN 16351 Timber Structures - Cross Laminated Timber standard. The test procedure was used to determine the stiffness and strength of three layer CLT Panels with 500 mm width, 135 mm thickness and 1215 mm, 1620 mm, and 4050 mm lengths (Support to support span). The configuration was chosen to allow for the central section of the CLT panel to be in pure bending without any shear force (*Figure 59* to *Figure 61*). Nine panels were tested in pure bending and a combination of shear and bending to confirm the performance of each CLT panel for bending strength, rolling shear strength and stiffness in different structural loading conditions. Experimental test results are presented in the load deflection diagrams (*Figure 59* to *Figure 61*). The results confirm that the test panels exceed theoretical calculations and associated numerical modelling.

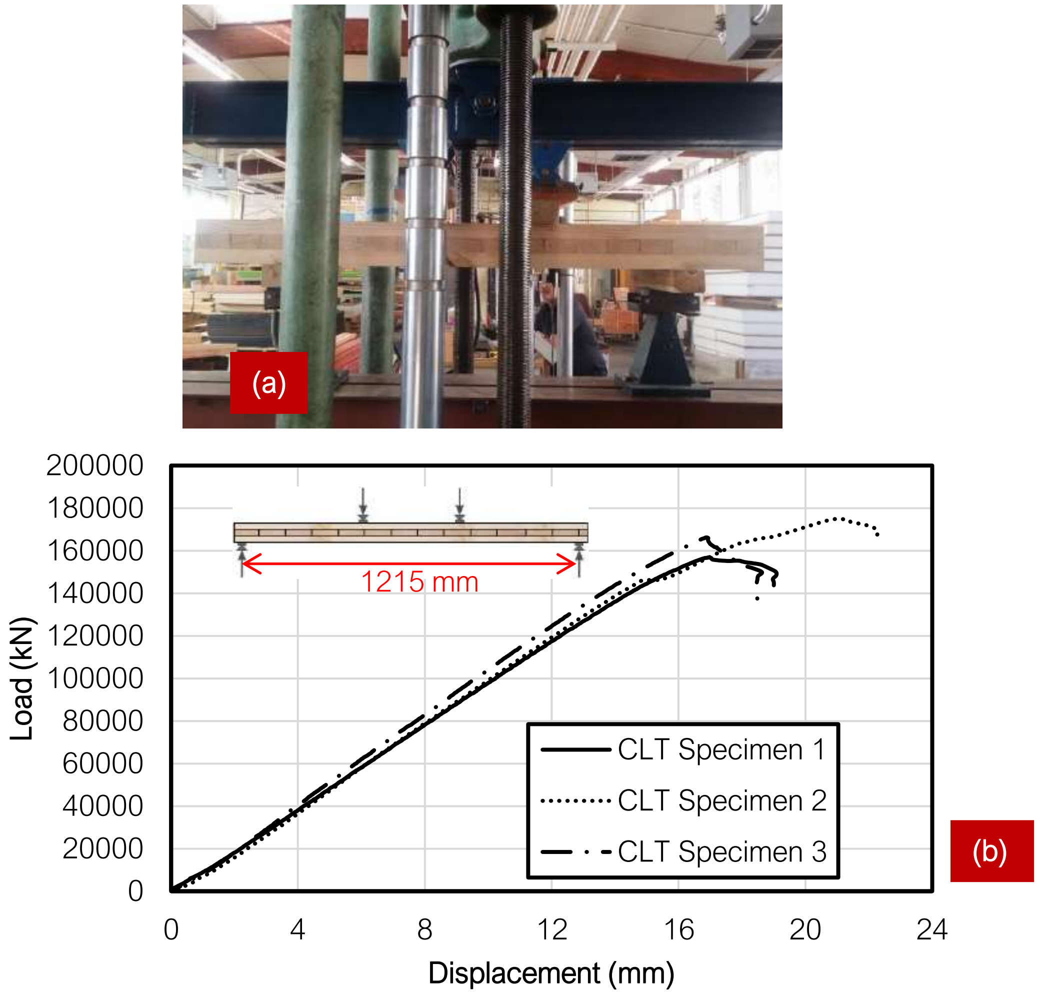


Figure 59: Rolling Shear Strength Test; a) Test setup for 135 mm thick Red Stag CLT Panel (Support to support span = 1215 mm); b) Load deflection diagram based on the recorded data by SCION.

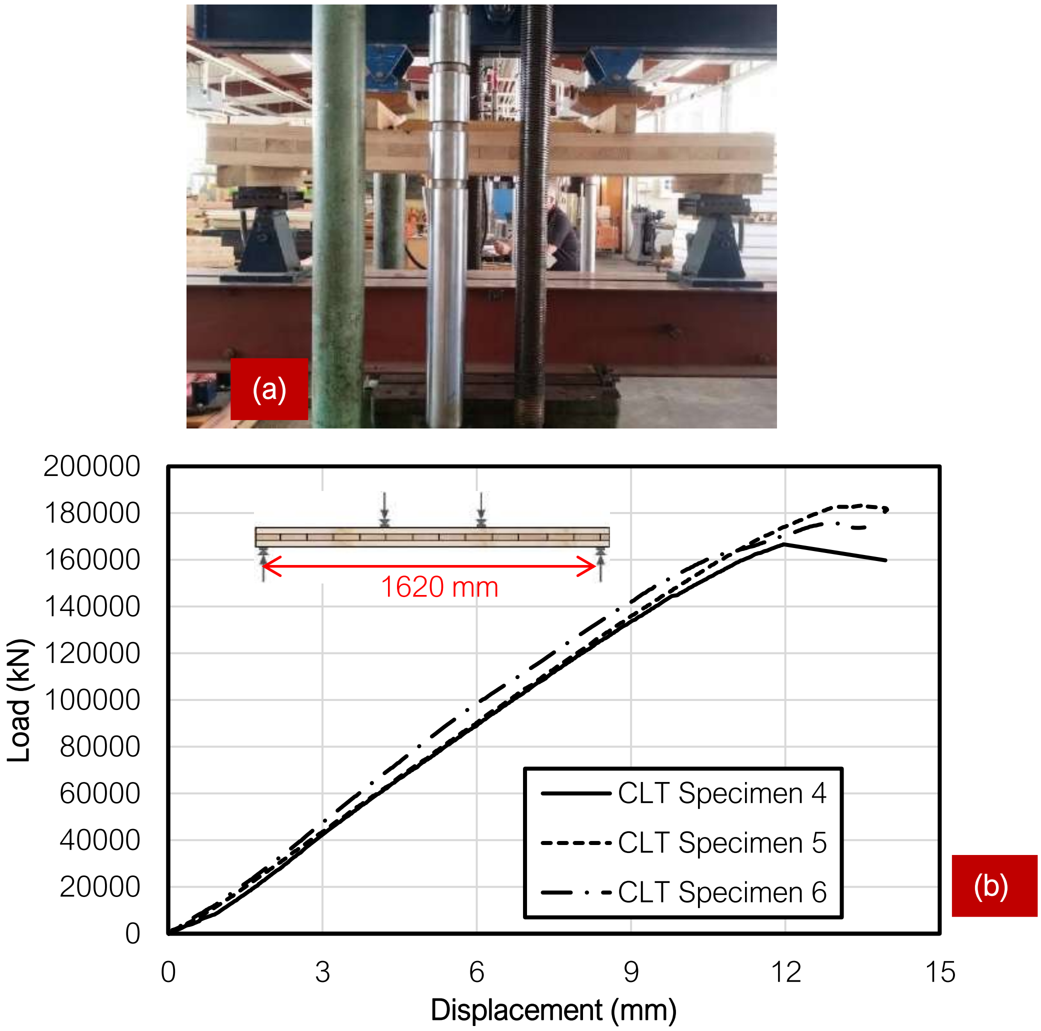


Figure 60: Rolling Shear Strength and Stiffness Test; a) Test setup for 135 mm thick Red Stag CLT Panel (Support to support span = 1620 mm); b) Load deflection diagram based on the recorded data by SCION.

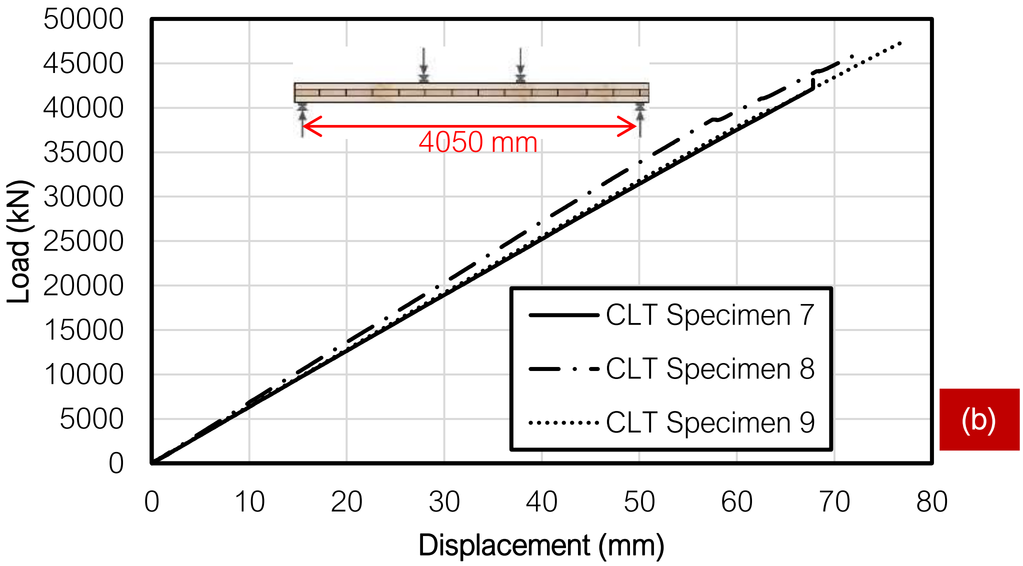


Figure 61: Bending Test; a) Test setup for 135 mm thick Red Stag CLT Panel (Support to support span = 4050 mm); b) Load deflection diagram based on the recorded data by SCION.

35.2.3 CLT Numerical Model

An experimentally verified numerical model was developed to predict the behaviour and structural performance of CLT panels. In order to check the accuracy of the numerical model, the deflection at the mid-span obtained from the numerical analysis was compared with the corresponding experimental test results. The summarised results in *Table 10* show that the numerical analysis has a direct correlation with the experimental test results. The minor differences between experimental and numerical results confirm the numerical model predicted the behaviour of CLT floors accurately.

Table 10: CLT Panel specifications and comparison of numerical and experimental results to verify numerical model.

Specimen Number	CLT size (mm) Width × Thickness × Length	CLT's planks (GPa) MoE_{L1}, MoE_{L2}, MoE_{L3}	Deflection (mm) Experimental Test [b]	Deflection (mm) Numerical Result [b]	Numerical Result / Experimental Result
Panel 1[a]	498×135×1620 498×(45+45+45)×4000	8,6,8	2.74	2.88	1.049
Panel 2[a]	498×135×1215 498×(45+45+45)×4000	8,6,8	1.85	1.92	1.037
Panel 3[a]	498×135×4188 498×(45+45+45)×4000	8,6,8	38.57	41.06	1.078

[a] Average of three tests repetition.
[b] Under 25 kN loading.

A 3D sketch and a typical Finite Element (FE) mesh adopted for CLT are shown in *Figure 62*. Roller and hinge supports in the numerical model were appropriately defined by restraining the nodes corresponding to the support points. To simulate the applied load in the numerical model, two incremental line loads at one-third increments over the CLT panel were applied with an initial increment of 1 N in the negative Y direction.

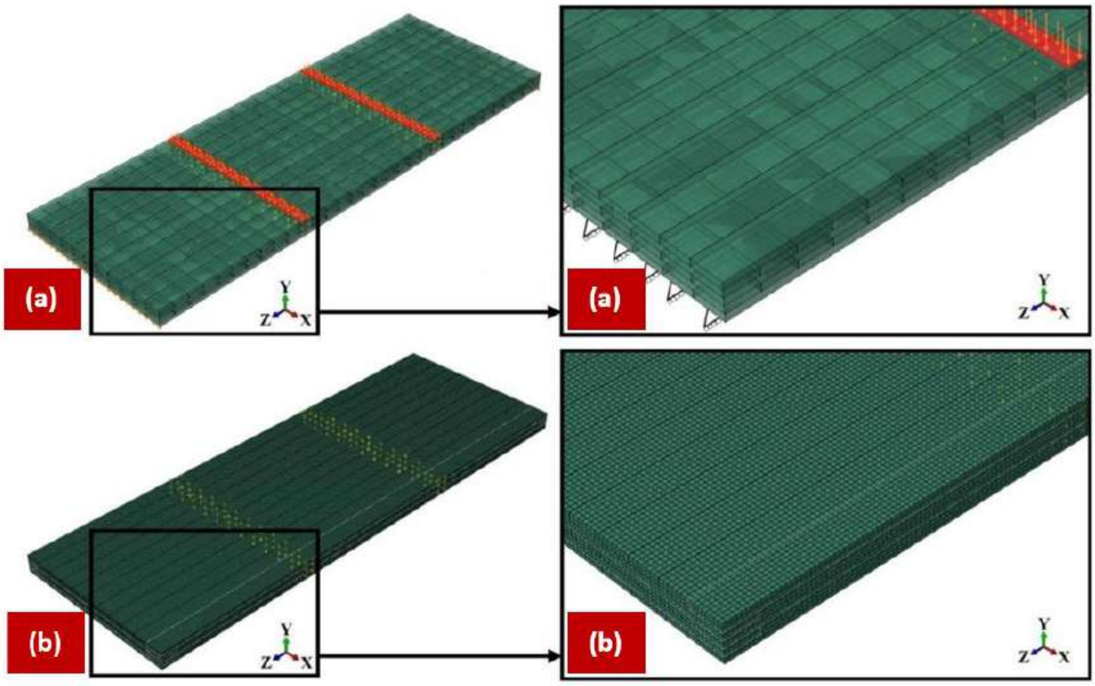


Figure 62: Typical boundary conditions and FE mesh used in the numerical model using ABAQUS software; (a) FE model boundary conditions (load and support); (b) FE mesh.

Provided evidence to support the verification of the numerical model showed that the model is accurate to predict the performance of other similar CLT recipes (layer configurations) under load based on New Zealand building standards.

The obtained numerical results presented in *Table 10* for the 135 thick CLT panel confirms that it is structurally suitable to carry the applied loads based on the New Zealand building standard. In parallel, the design calculation based on the FPInnovation CLT Hand Book confirm the panels structural suitability.

35.3 Schedule 3: Red Stag CLT Floor Fire Test

35.3.1 Red Stag CLT Floor Fire Test

Red Stag produced and supplied a single continuous CLT fire test panel, free of penetrations with the following dimensions: 3.95 m x 3.4 m x 0.103.5 m (L x W x D). The panel was placed into a fire testing frame at the laboratory, supported by the two ends perpendicular to the longitudinal lamellas.

Details of the CLT specimen are presented in *Table 11*, *Figure 63a* and *Figure 63b*.

Table 11: Three layer test specimen details.

Total CLT Thickness	103.5 mm
Layer One	34.5 mm MoE 8 GPa lamellas; 3.40 m
Layer Two	34.5 mm MoE 6 GPa lamellas; 3.95 m
Layer Three	34.5 mm MoE 8 GPa lamellas; 3.40 m
CLT configuration: Layer one and three were perpendicular to layer two. The layers were adhered to one another using Polyurethane (PUR) adhesive.	

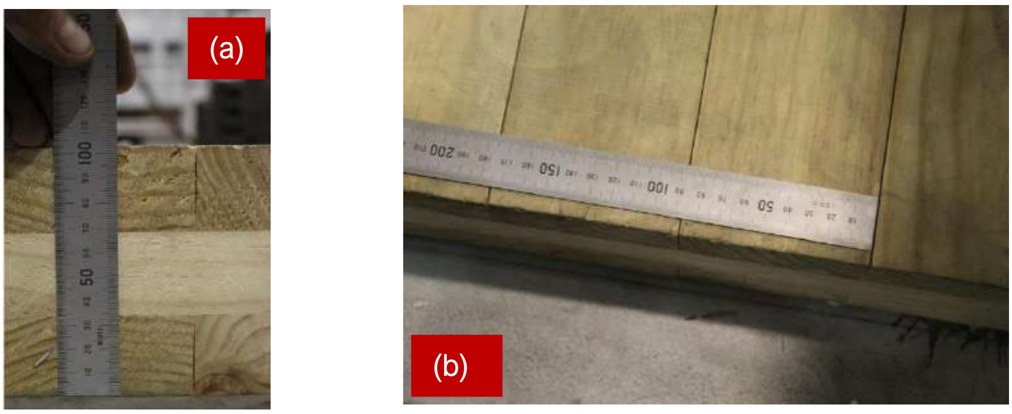
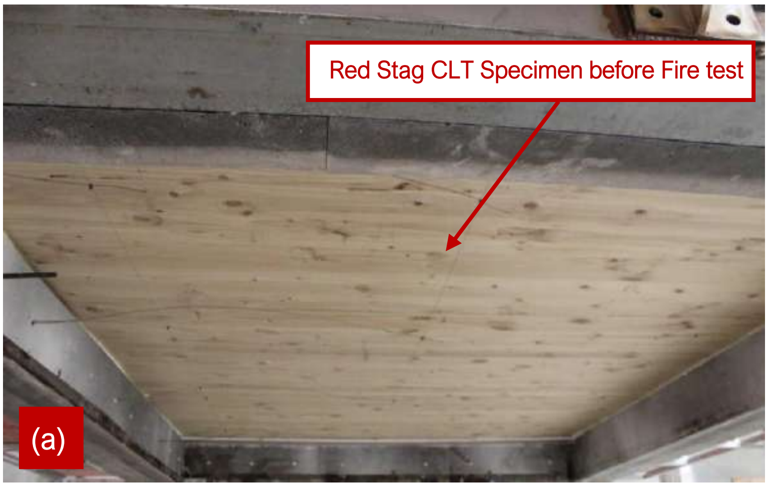


Figure 63: Red Stag CLT system and lamella dimensions.

The test result confirmed that 103.5 mm thick panels (34.5-34.5-34.5) can exceed 60 minutes under fire conditions; therefore, extrapolation confirms that thicker panels will also exceed the 60 minutes result. *Figure 64a* and *Figure 64b* show the CLT panel before and after the fire test and *Table 12* shows an extract of the test report summary from the fire laboratory (refer to the *Red Stag Regulatory Fire Information Report 1.1*).



Red Stag CLT Specimen details for fire test:

- Timber moisture content: 11.8-14.6% (15 measurements).
- Recipe details making up the overall 103.5 mm thickness:
  - Layer 1*: 34.5 mm, MoE 8 GPa, 3.40 m
  - Layer 2*: 34.5 mm, MoE 8 GPa, 3.95 m
  - Layer 3*: 34.5 mm, MoE 8 GPa, 3.40 m

  *Layers one and three are perpendicular to layer two.
- Polyurethane (PUR) adhesive was used to bond layers together.

Figure 64: 103.5 mm thick Red Stag CLT Specimen; (a) Test specimen before the fire test; (b) Large scale fire test setup and specimen after fire test.

Table 12: Laboratory fire test results [a].

Specimen	Dimensions	Structural Adequacy	Integrity	Insulation	FRL
Three-layer CLT Floor Panel	Width: 3.95 m Length: 3.4m Thickness: 0.1035 m	62	62	62	60/60/60

[a] Extract from the third party testing laboratory fire test report.

Section 5

Red Stag Panel Assembly & Site Guide

Make it better

Red Stag Project Guide V1.0
August 2022

RED STAG® WOOD SOLUTIONS

36. Introduction

Mass timber buildings are constructed using a natural resource, configured as an EWP. Products that exist under the umbrella of mass timber include CLT and GLT. Mass timber elements (including beams, columns, and panels) require specifically designed assembly and connection details. Whilst this guide cannot account for all the various permutations of assembly and connection detailing on a project (as they are often unique), it does provide some general advice regarding the connection and assembly of mass timber elements.

37. Element Configuration

Red Stag produces a combination of panels, beams, and columns to enable the majority of mass timber construction solutions. Typically, Red Stag elements are produced using at least three layers. CLT elements have layers arranged at right angles to one another, and GLT has all layers running in the same direction. Hybrid options also exist for band beams, where one or both faces have multiple layers of GLT sandwiching CLT layers. Red Stag can manufacture some of the largest CLT elements in the world, with panels up to 16.5 m x 4.5 m x 0.42 m (Length x Width x Depth). Red Stag can manufacture GLT up to ~17.0 m x ~3.0 m x 0.43 m.

CLT can be used in the following applications (refer to *Figure 65*).

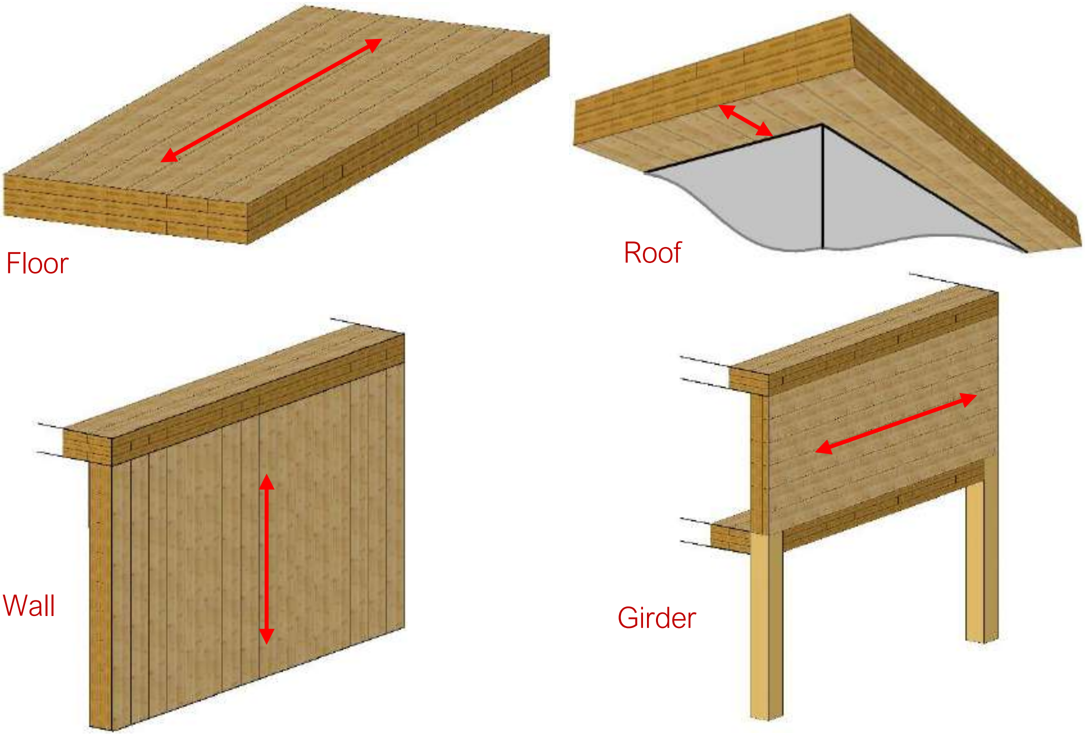


Figure 65: Typical CLT applications and associated panel directionality.

Note: Girder can be a header or deep beam, depending on the design of the panel and its placement in the superstructure.

39. Load Bearing Effect

The ability to interlock CLT improves the system performance (structural, fire and acoustic). The horizontal elements such as floors and roof systems are predominately stressed in a single direction (uniaxial); however, applications exist to load elements in two directions (typically associated with symmetrical element configurations). Vertically configured elements such as walls have comparatively high shear stiffness due to the interlocking layers.

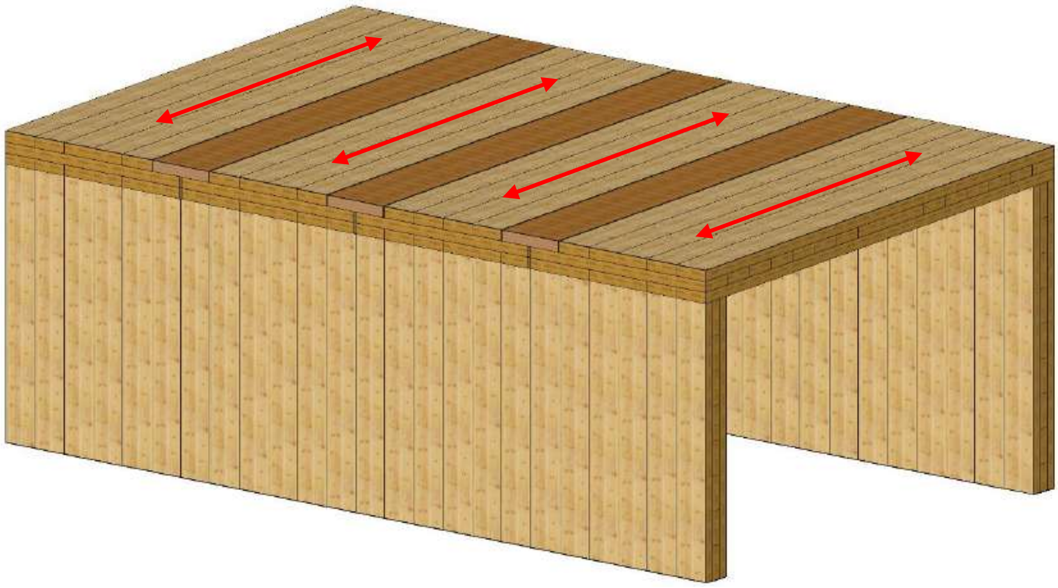


Figure 66: Load-bearing effect of floor panels on wall structures.

The main direction of the load-bearing capacity typically corresponds with the direction of the outer layers in EWP elements. The primary direction for load bearing capacity (0°) is the stiffest, whilst the ancillary direction of load -bearing capacity (90°) has a lower stiffness (refer to *Figure 67*).

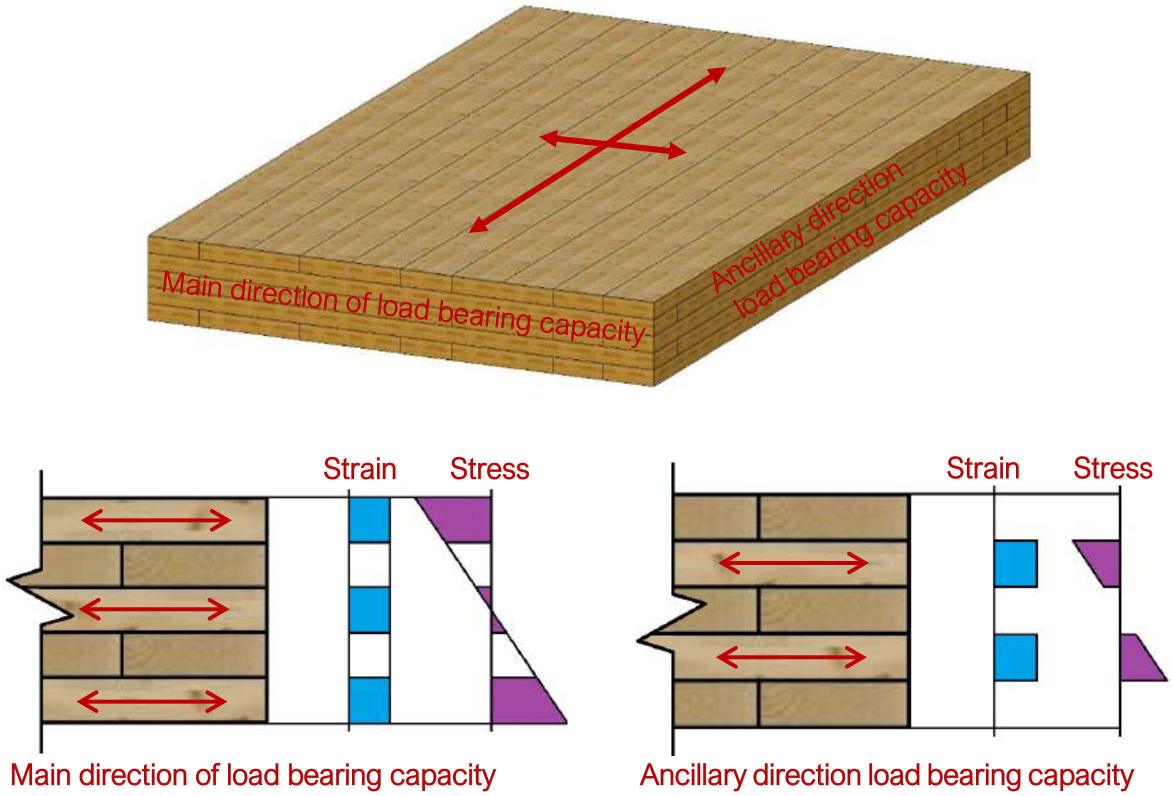


Figure 67: Directionality of the main load-bearing capacity of a floor panel.

Only the lamella acting in the load bearing direction form part of the calculation to determine the load-bearing performance for panel bending in a single direction. The traverse lamella are not assigned longitudinal stresses in the calculation, therefore the MoE transverse to the fibre is assumed with E90 = 0. Thus, the transverse layers are considered as spacers and only subjected to shear.

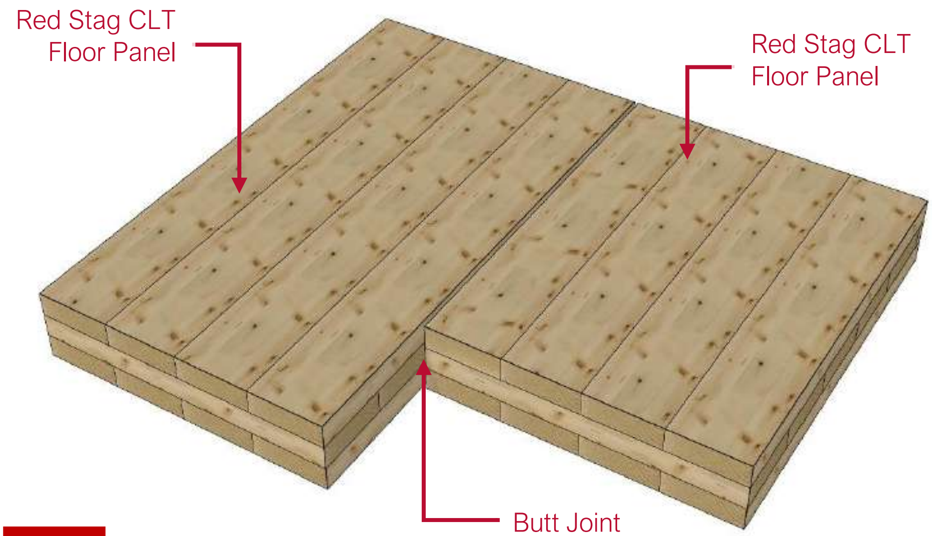
40. Understanding Panel Jointing

There are several typical ways to joint panels:

1. Butt joint (refer to *Figure 68a*).
2. Lap Joint (refer to *Figure 68b*).
3. Spline Joint (refer to *Figure 68c*).

The selected jointing solution needs to manage three primary considerations: structural performance, fire resistance, and acoustic requirements.

To use CLT as a lateral load resisting system, panels need to be connected. For in-plane shear connections, panels can be joined with self-tapping-screws into surface splines and/or half-lap joints. In some applications screws can be installed at an angle to the plane, allowing simple butt joints to be utilised. Butt and spline joints generate the least amount of waste as the entire panel surface area can be utilised (lap joints generate less coverage due to the lap wastage). Butt joints reduce Computer Numerical Control (CNC) machine time.



(a)

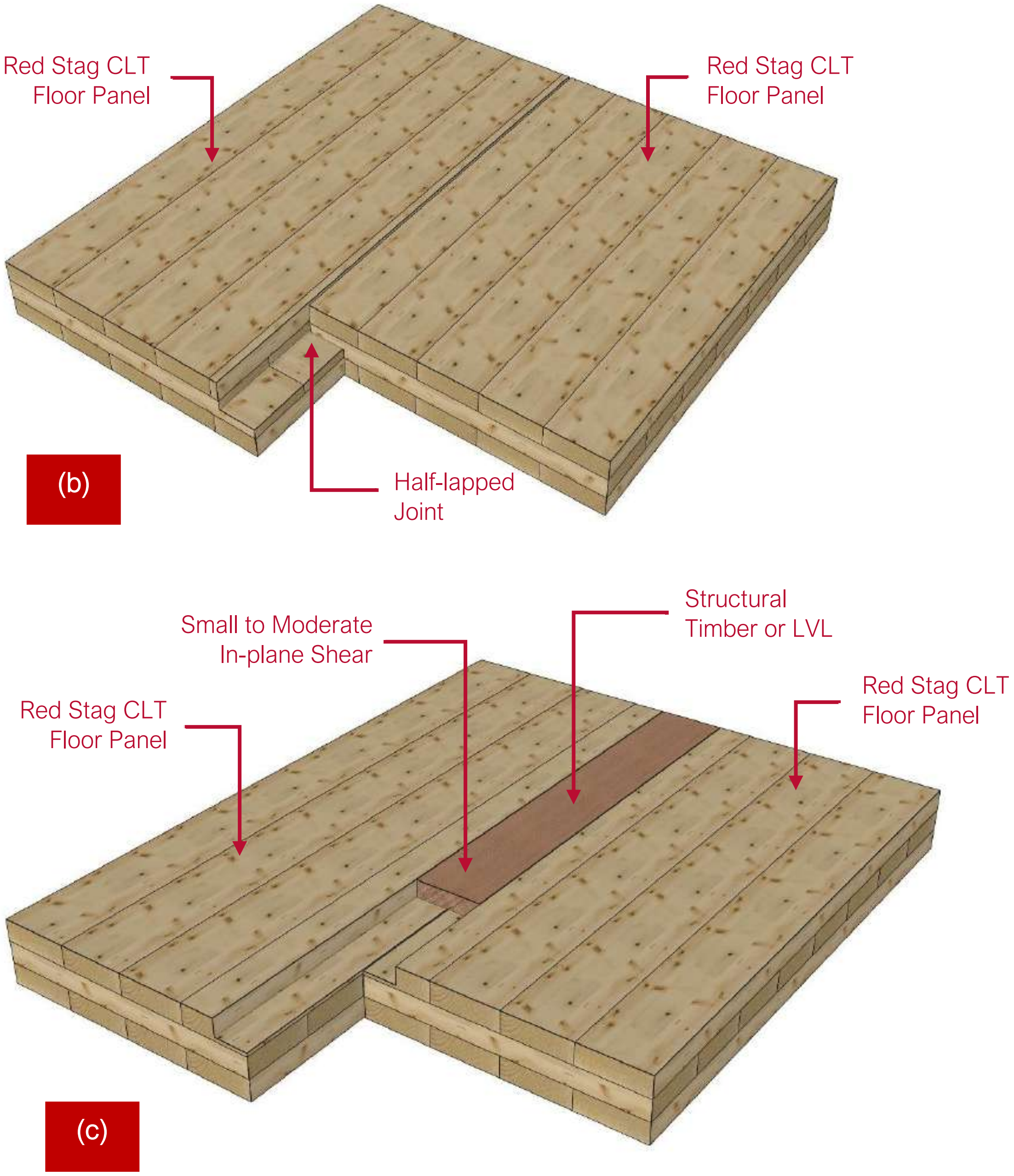


Figure 68: Typical panel jointing options; a) Butt Joint; b) Lap Joint; c) Spline Joint.

40.1. Joint Details and Processing

Red Stag predominantly machines EWP elements on complex five axis CNC equipment. Details on the machining and joint assembly are listed below:

40.1.1 Butt Joint

A butt joint occurs when panels are placed side-by-side on-site and are interconnected with raking screws to tie panel edges together. Screws are typically placed on an angle of 45° to the edge of the CLT panels, and at an angle of 35° to the face of the panels [18].

40.1.2 Half-Lap Joint

A half-lap joint is typically formed by opposing rebates on the faces of adjacent panels. To simplify panel machining, Red Stag recommend lap rebates to half the panel depth, machined perpendicular to the face. The horizontal width of the laps are commonly 80 mm wide to reduce panel wastage, while providing sufficient flange width for fixings. Red Stag uses every attempt to machine laps without the need to flip the panel. If lap joints are wider, it may require panels to be flipped, increasing the machining time and associated costs [18].

40.1.3 Spline Plate Joint

Spline joints can be on one or both faces depending on the application. Single sided spline joints are the most common and have the advantage of reduced panel machining, and only require machining from one face.

Spline joints are machined in a similar manner to the under lap detailed in 5.1.2 above. Spline joints require a secondary spline board to bind panels. Depending on the application, splines can be solid timber, LVL or even ply. Spline joints are only machined to the depth of the spline, which are typically 20 – 45 mm deep. Spline rebates are machined to half the width of the spline plus the panel separation tolerance. Typically spline joints are designed to accommodate a spline board between 120 – 140 mm wide, providing sufficient face area for screws to bind the spline plate with underside of the spine lap without causing any splitting [18].

A wide variety of fasteners and associated connection details can be used to establish element connectivity in timber and hybrid (concrete, steel and timber) structures.

While self-tapping screws designed for mass timber are typically recommended for EWP systems to connect elements, traditional dowel-type fasteners such as wood screws, nails, lag screws, bolts, and dowels can also be effectively used if designed correctly. Other types of traditional fasteners, including bearing type fasteners such as shear and tooth plates, may also be suitable; however, their use is generally limited to applications where lower loads and forces are involved.

There are a wide range of CLT connection methods and fasteners available to combine floor, wall, and roof assemblies. A series of some of the most common structural connection details in timber and hybrid buildings are illustrated in *Figure 69* to *Figure 81* below.

41.1 Red Stag CLT Wall Panel to Concrete Foundation/Floor Connection

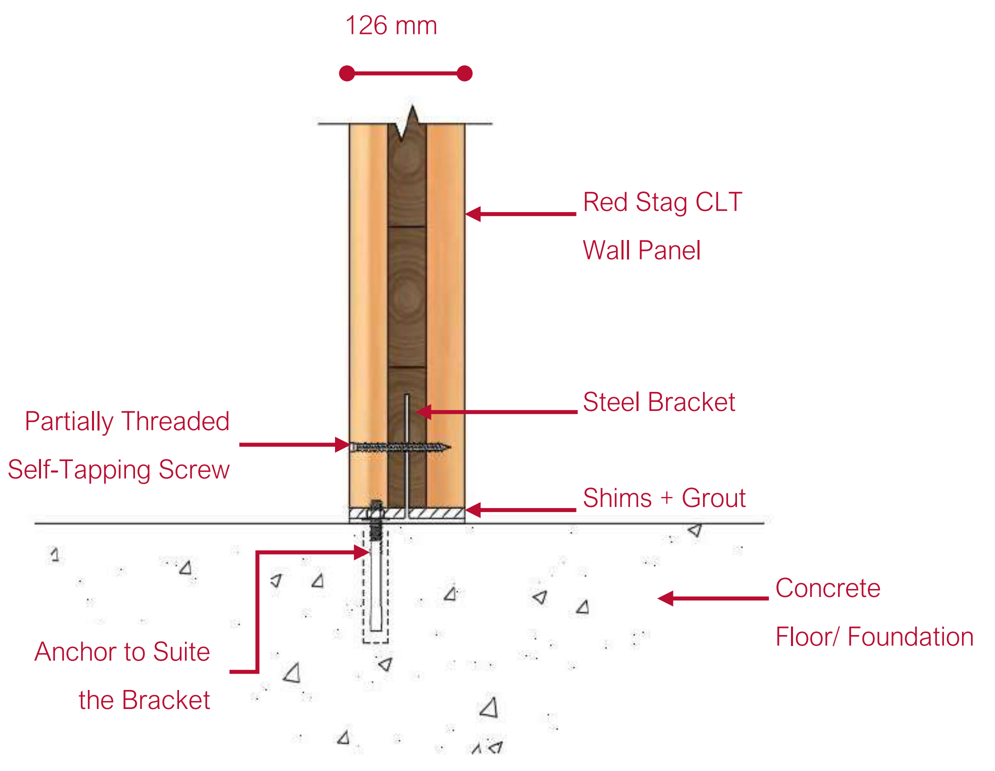


Figure 69: Internal Red Stag CLT wall to the concrete foundation/floor connection.

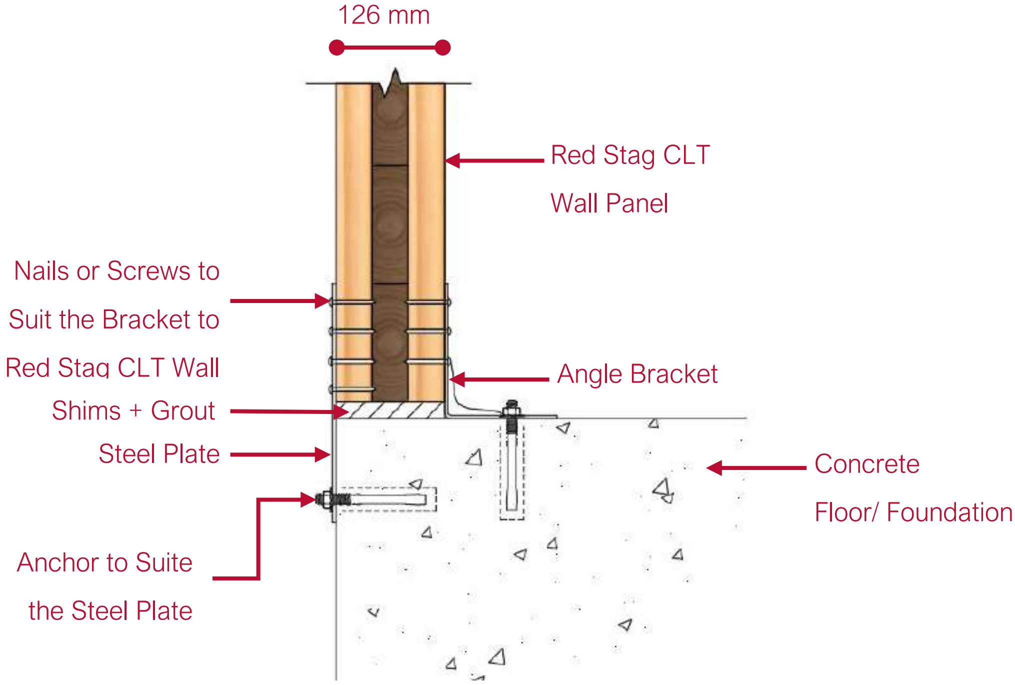


Figure 70: Red Stag CLT wall panel to the concrete foundation/floor (On edge of external walls of the building).

41.2 Red Stag CLT Wall Panel Connection

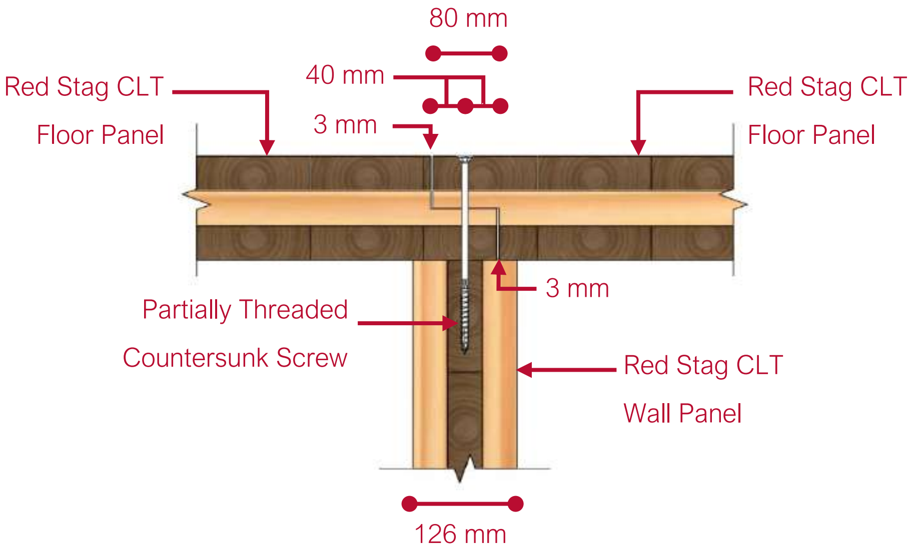


Figure 71: Red Stag three (3) Layer CLT wall panel to CLT floor panel half joint connection.

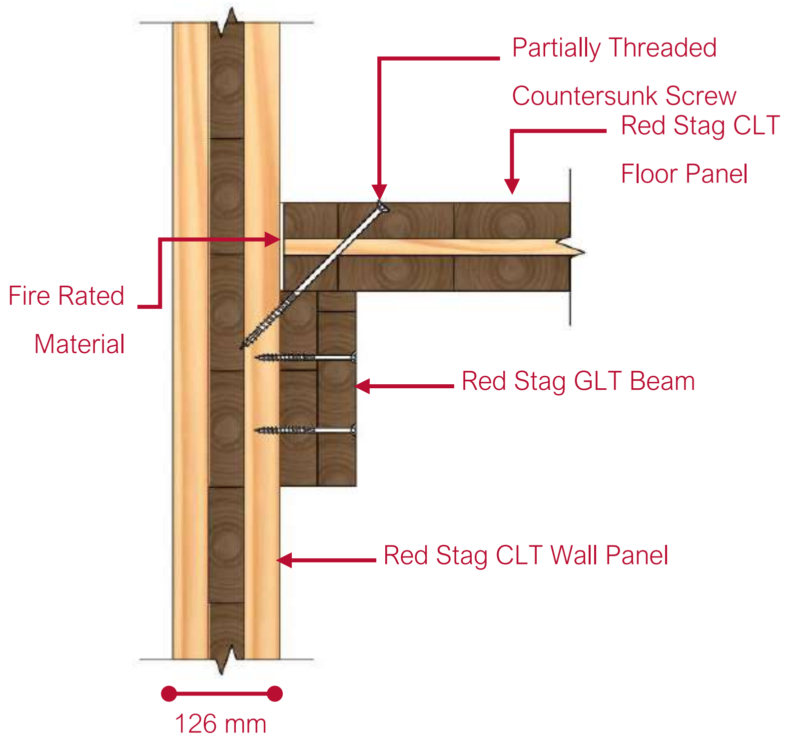


Figure 72: Red Stag CLT wall panel to CLT floor panel (On edge of external walls of building).

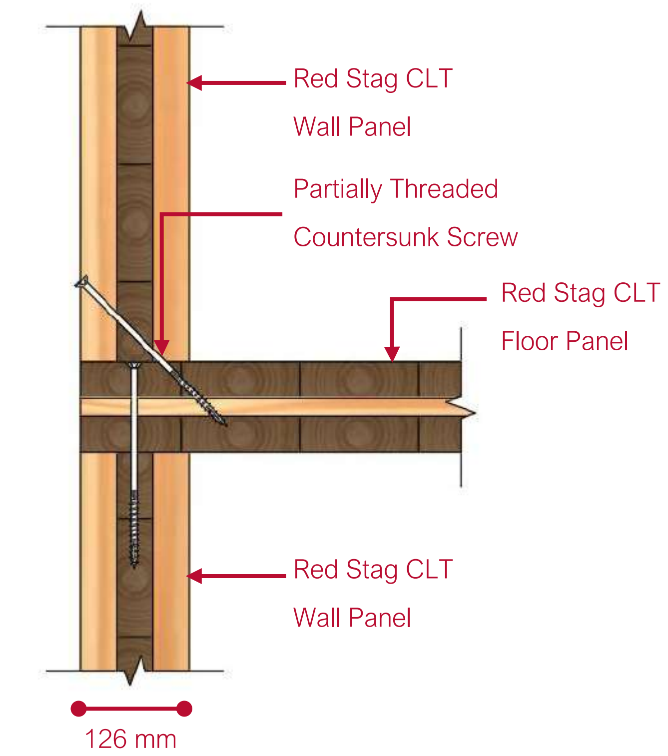


Figure 73: Red Stag CLT wall panel to CLT floor panel.

41.3 Red Stag CLT Roof Panel Connection

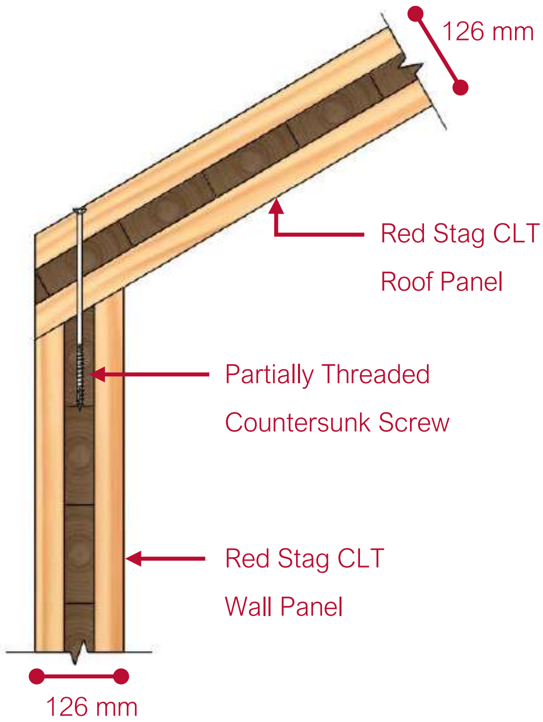


Figure 74: Red Stag three (3) layer CLT roof panel to CLT wall panel connection.

41.4 Mixed Timber Connection to Red Stag CLT Connections

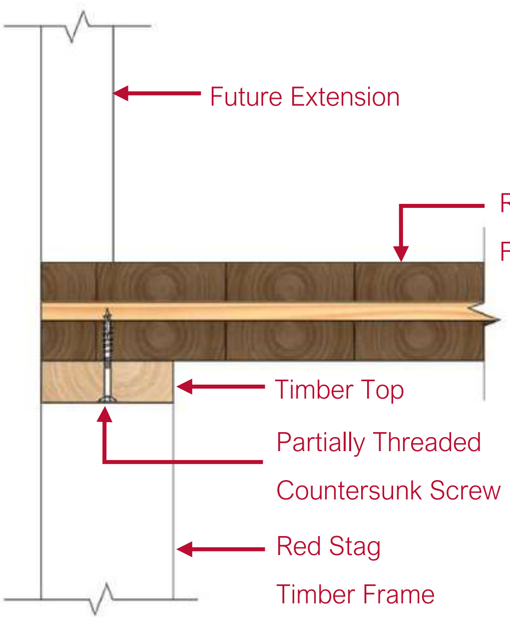


Figure 75: Timber frame wall to Red Stag CLT floor panel connection.

41.5 Red Stag CLT Floor Connection

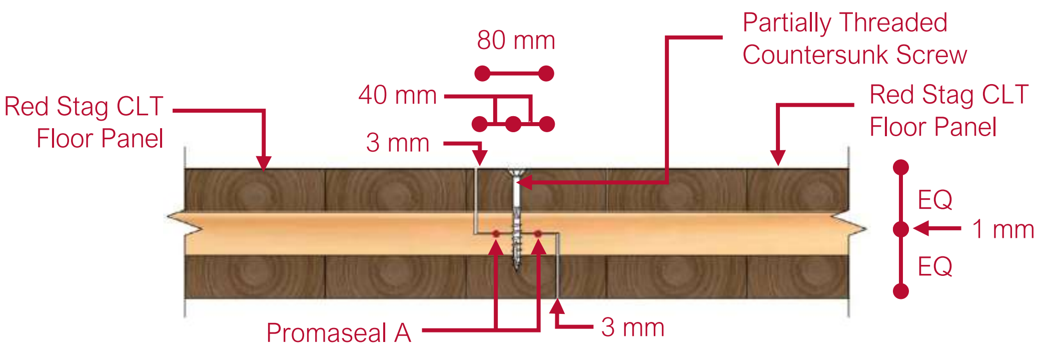


Figure 76: Red Stag three (3) layer CLT floor to floor half-lap joint connection.

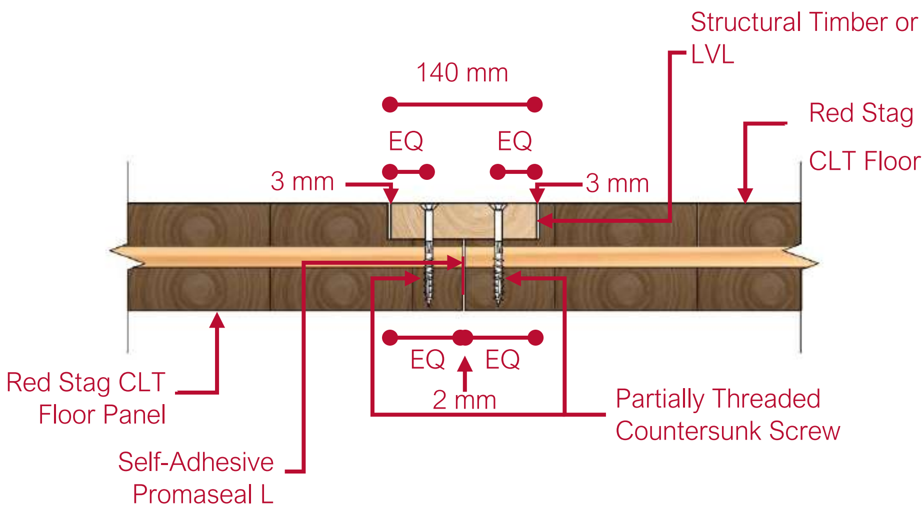


Figure 77: Red Stag three (3) layer CLT floor to floor with spline plate connection.

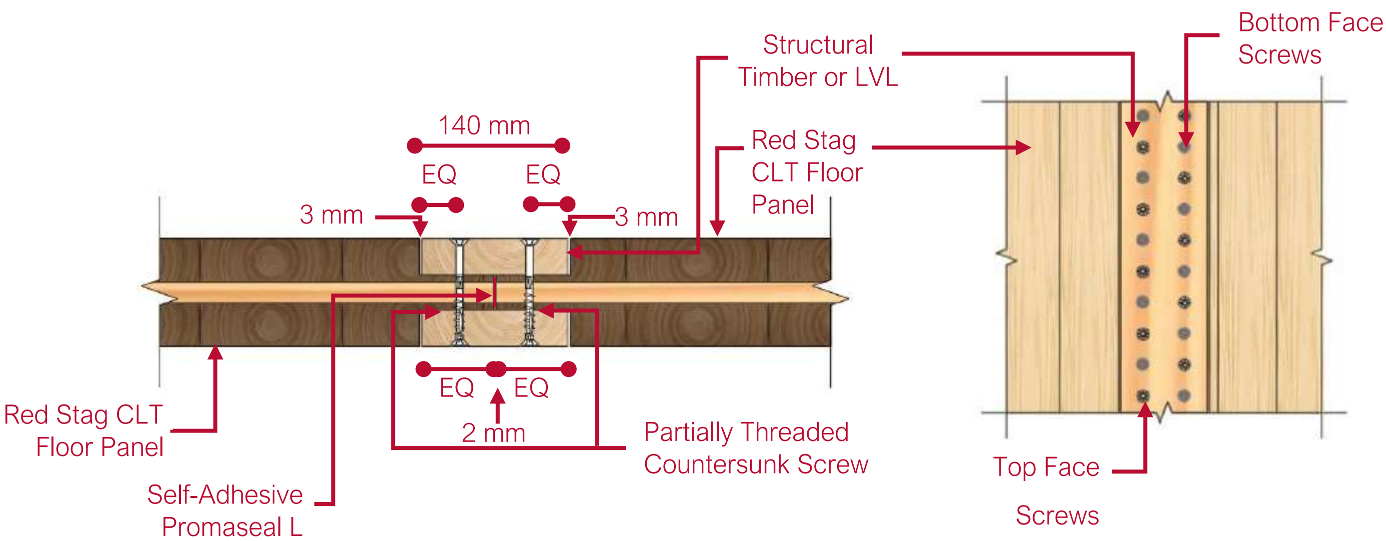


Figure 78: Red Stag three (3) layer CLT floor panel to floor panel with double spline plate connection.

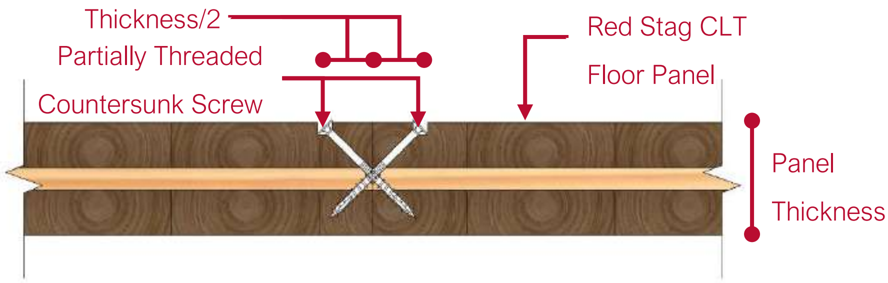


Figure 79: Red Stag three (3) layer CLT floor to floor butt joint connection.

41.6 Red Stag CLT Stair Connection Details

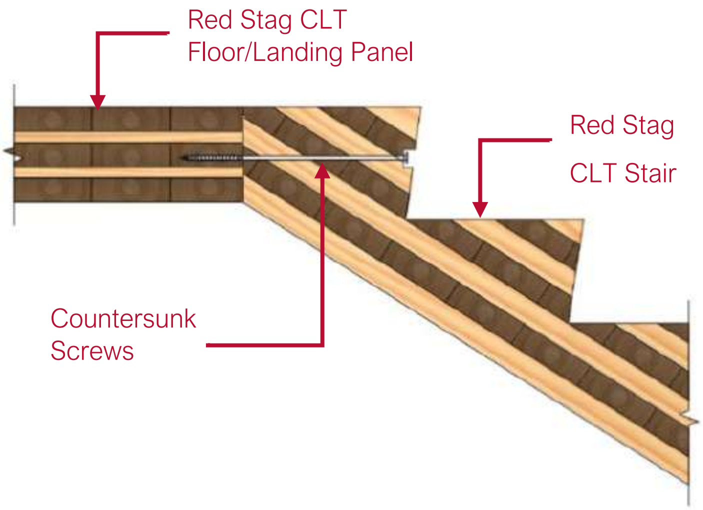


Figure 80: Red Stag CLT stair panel to CLT landing/floor panel connection.

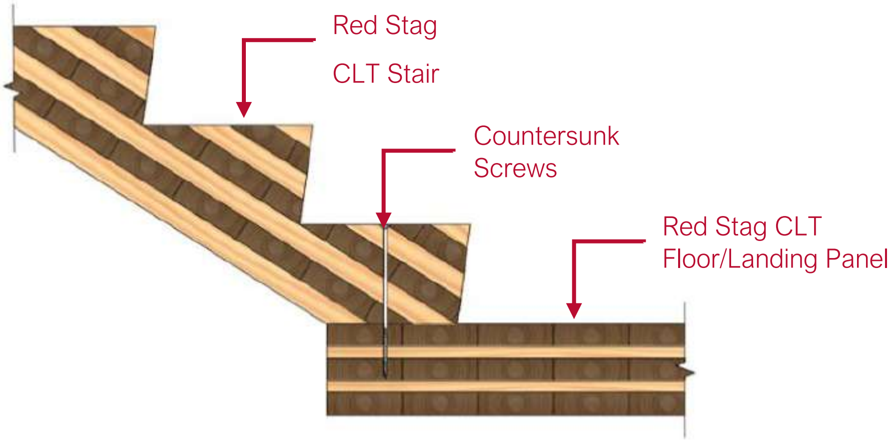


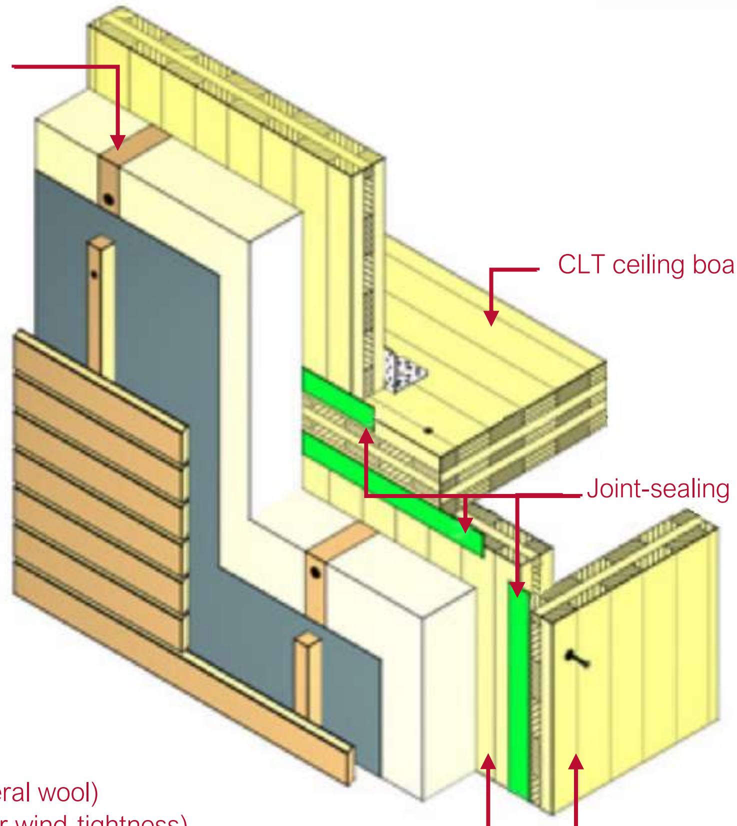
Figure 81: Red Stag CLT stair panel to CLT landing/floor panel connection.

42. Construction Build-Ups

Mass timber wall and floor assemblies can have a wide range of compositions subject to the application and performance criteria. The following figures illustrate examples or a wide range of mass timber system assemblies.

42.1 External Applications

42.1.1 External Cladding Assembly



Structure:

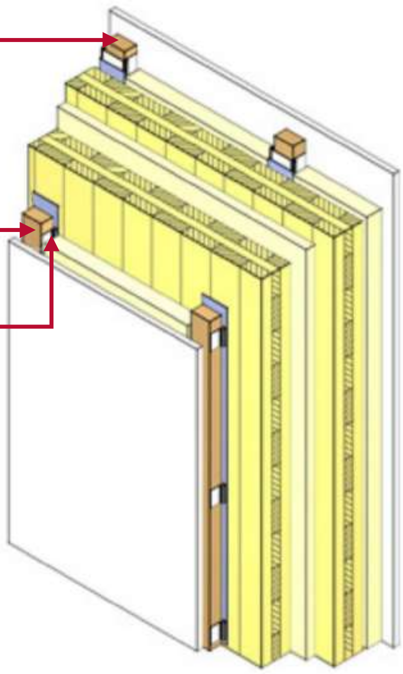
- CLT wall board
- Insulation (mineral wool)
- Vertical seal (for wind-tightness)
- Battens
- Horizontal wall cladding

42.2 Internal Applications

42.2.1 Partition Wall Applications

Isolated facing panel (free-standing or on spring clips)

Spring clip (sound insulation)



Structure:

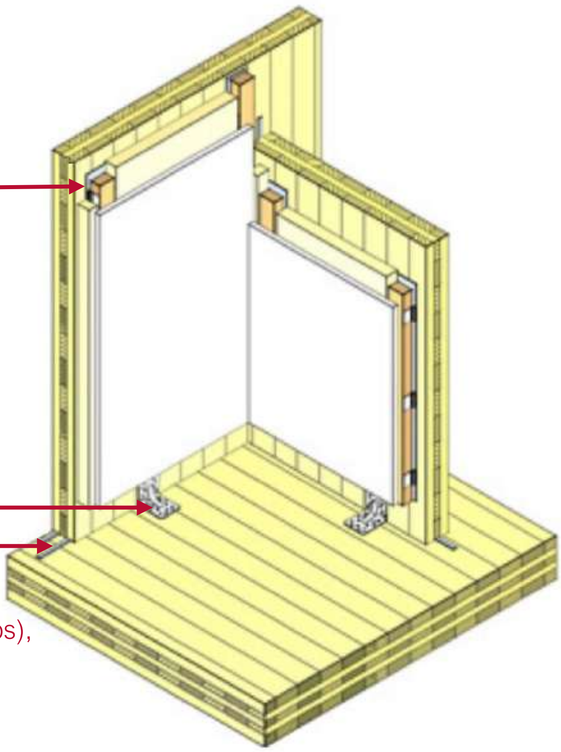
- Gypsum cardboard or gypsum fiberboard
- Battens (fastened with spring clips), insulation (between battens)
- CLT wall board
- Impact sound insulation
- CLT wall board
- Battens (fastened with spring clips), insulation (between battens)
- Gypsum cardboard or gypsum fiberboard

42.2.2 Internal Wall Structure

Insulation strip (between CLT and battens)

Wall anchorage (according to structural requirement)

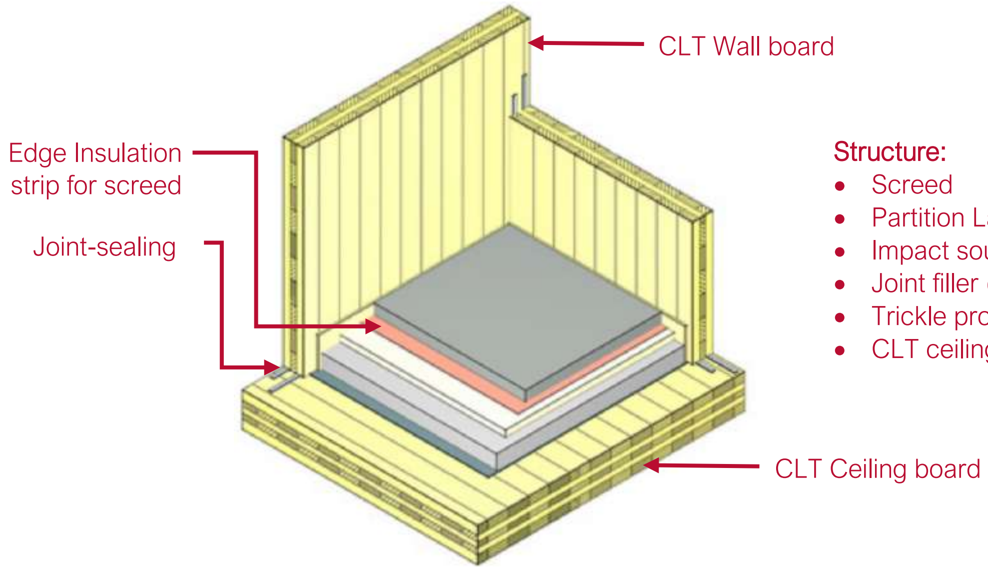
Joint-sealing tape



Structure:

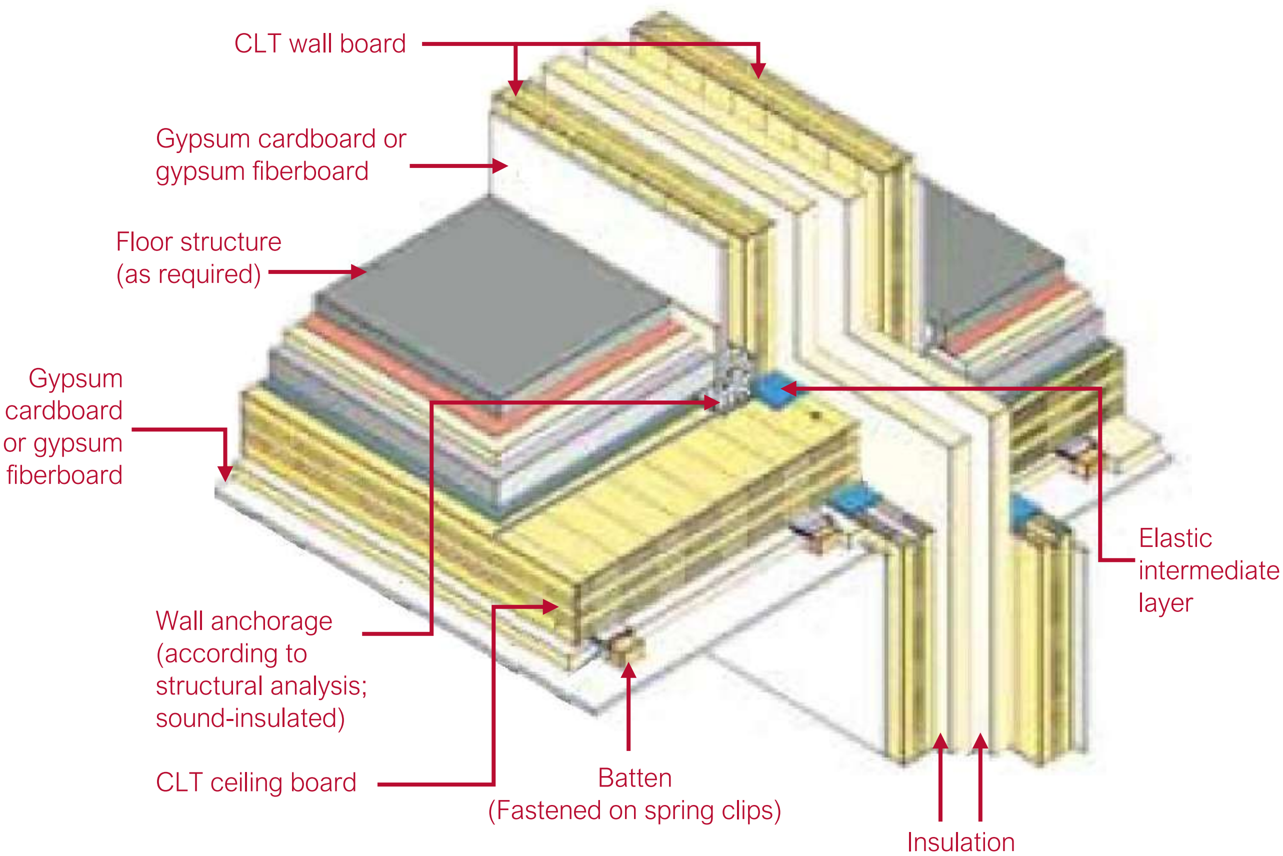
- CLT wall board
- Battens (fastened with spring clips), insulation (between battens)
- Gypsum cardboard or gypsum fiberboard

42.2.3 Floor Structure Wet Areas



Structure:
- Screed
- Partition Layer
- Impact sound insulation
- Joint filler (gravel)
- Trickle protection (optional)
- CLT ceiling board

42.2.4 Multi-storey Wall-Floor-Ceiling Connections



43.1 Transportation

Red Stag typically configures bundles of EWP to allow for them to be transported on flat-deck trucks. In line with the quotation documents, Red Stag design transportation loads for them to be unloaded in bundles to reduce the time transportation units are required on site and the associated costs to the Client. This requires that the receiving site has an adequately sized crane for both the load and reach, and an adequate lay down area at the construction site to transfer the bundle(s) to prior to being integrated into the project. The option may exist for the transportation unit to be unloaded element by element, to allow for direct integration and assembly into the project from the transportation unit; however, this needs to be agreed in advance with Red Stag and priced accordingly, as it significantly increases the time that the transportation unit is required on site.

43.2 Unloading from Truck in Bundles to Staging Area

EWP elements need to be unloaded in bundles (typically one bundle per transportation deck) upon arrival and transferred to a staging area on site. This option is the standard solution quoted by Red Stag to reduce the required transportation unit time and associated costs. Red Stag allow for a maximum of one hour from the time that the transportation unit arrives on site to the time that it departs. The Client needs to ensure that the crane is sized appropriate for the bundle size, mass and has sufficient reach capacity based on the load. The Client also needs to ensure that the staging area adheres to all of the EWP storage requirements, including but not limited: level and suitably supported, adequately elevated above the ground, free of surface and flowing water, suitably protected from the elements, etc.

43.2.1 Advantages

- Reduces transportation time on site, expediting deliveries and reducing transportation costs.
- Provides the site assembly team with control and flexibility on the assembly process (material on site ready when the assembly sequence allows or when resources such as cranes are available).

43.2.2 Disadvantages

- Requires additional room on site to store bundle(s) of EWP.
- Requires storage area preparation to ensure that the site is level, free of surface and flowing water, and has adequate dunnage, etc.
- Requires the Client to protect the EWP bundles from the elements (e.g. rain, sunlight, etc).
- Typically requires a larger crane (greater lift capacity).

43.3 Site Assembly Unloaded Directly from the Truck

Red Stag can price (typically only an estimate as the final time on site is variable and is charged at the applicable hourly rates) and coordinate additional transportation time on site to allow for the EWP to be unloaded element by element, and directly installed from the truck to minimise double handling of members. Through the shop drawing process (refer to *Red Stag Project Guide*, *Section 1*), Red Stag bundle members to coordinate as closely as practically possible to the Client intended assembly sequence; however, the requirement for safe transportation means that some members may not be in the precise order required by the Client and may still need to be staged before they can be installed on site.

43.3.1 Advantages

- Reduces double handling of EWP elements onsite.
- Typically reduces the staging area required on site.
- Typically reduces the size of the crane onsite.

43.3.2 Disadvantages

- Transportation unit time and costs on site are reasonably increased.
- The coordination of deliveries and crane time needs to be managed to optimise the process.
- Installation sequence and timing is inflexible – the sole focus of the crane and team is unloading and assembling the elements off of the transportation unit. Any delays continue to increase delivery charges.

43.4 Bundling

Red Stag prepared EWP elements into bundles. The size of the bundles are typically as large as possible based on lifting devices and transportation dimensions. Each layer in a bundle is separated with dunnage (typically 20 – 50 mm thick). The base dunnage separating the deck of the transportation unit to the underside of the first layer of EWP is typically between, 120 – 210 thick (required based on the tyne thickness of the loading forklift at Red Stag). The bundles are not typically pre-strapped at Red Stag, relying on the transportation carriers' strops to safely transport the load (the transportation carrier is responsible for the stability of the load for transport and must ensure that the load(s) are safely secured before they can leave the Red Stag site).

43.5 Delivery Process and Notifications

It is the responsibility of the Client (including assigned representative(s)) to carefully inspect the condition and quantities of the delivered elements (including fixings and ancillary components) while they are still on the delivery vehicle. The Client must ensure that scheduled delivery matches the delivery documentation and associated load before any unloading process commences. If the load is incorrect, the Client must immediately notify Red Stag (for expedience, a telephone call followed by supporting written communication) and a process can be managed, which may include the load leaving the site.

If material is missing or has been damaged in transit, all details must be defined on the delivery documents by the Client and Red Stag should be notified immediately with scans and photos to follow as soon as practically possible on the date of delivery. It is essential that the precise details on any damaged or missing component(s) is noted (e.g. number of units damaged or missing with their precise reference, element number damaged, type of damage, etc) on the documentation with the details on the representative (e.g. contact name, position and contact details, etc) documenting the issue and should include clear photographs of the broader load and zoomed in area to help put the issue into perspective.

If a delivery takes longer than expected (typically defined as one hour in estimates and quotations), the Client will be charged for and is responsible for paying the additional transportation unit time on site within seven calendar days of receiving the invoice (GPS logs on transportation units generally support in simplifying the process). Transportation drivers will also likely request the Client sign the receipt of goods including the time of arrival and departure.

43.6 Loading Plans

Red Stag will bundle EWP elements as defined through the shop drawing process and confirmed by the Client via the *Project Lifting & Scheduling Approval Form* (refer to *Appendix C*). This process manages the Client targeted sequence with load restrictions to ensure that the bundles are stable in transit. If the final load sequence(s) compromises safety or the truck driver refuses to carry the load due to stability concerns, the load sequence will have to be altered.

43.7 Unloading

On arrival, if unloading with a forklift or similar, it is necessary to have forks that are long-enough to support the width of the bundle(s), and that the equipment has a sufficient lift rating based on the load centre and width of the bundle(s).

If the bundle(s) are being unloaded via crane, appropriately rated crane, lifting strops, hitches and rigging are required to sling under the bundles. Based on the length and width of the load, spreader bar(s) are likely required to evenly distribute the load to ensure that the mass timber elements are evenly supported.

If the mass timber elements are being unloaded member, by member, the lifting system assigned/agreed by the Client must be used in conjunction with rated fixings and rigging.

43.8 Unloading Safety

Red Stag understands that there are inherent risks with unloading large heavy elements. It is the responsibility of the Client or the Client representatives (e.g. contractor/assembler, crane/fork operators, etc) when unloading and lifting to take all necessary care and precautions to protect personnel and equipment according to all applicable regulations, laws and safety recommendations. Elements are to be offloaded in designated safe or restricted area(s). It is important to ensure that there are no people under or in proximity to the potential fall path of loads while being lifted. The unloading area must be supervised, and the truck driver is not responsible for offloading. Delivering transportation agents (e.g. truck drivers) are not responsible for lifting and offloading Red Stag EWP elements and supplied materials. Transportation agents should remain in their cab unless directed by the Site Safety Officer. Prior to any lifts, the transportation agent must ensure that the transportation driver(s) are in a safe designated area outside of any potential fall zone. Refer to the *Section 2* (*Red Stag Lifting Guide*) for more details.

43.9 Factory Fitted Wrap and Transit Protection

Red Stag uses best endeavours to minimise the use of single use plastic(s) to provide weather protection to its manufactured elements. Wherever practically possible, Red Stag stores manufactured products under heavy duty multi-use tarpaulins. In parallel, Red Stag encourages transportation partners to utilise multi-use tarpaulins to transport product(s) to site.

At times, Red Stag may utilise single use plastic wrap, but will try and minimise the volume of wrap by installing around bundles as opposed to individual elements.

Building envelope wrap may be affixed in factory if agreed between the Client and Red Stag, but will still require secondary weather protection for storage and transportation. Refer to the *Section 3* (Red Stag Building Envelope Guide) for more detail.

43.10 Protection of Visual Grade Panels

Some Red Stag elements are manufactured and processed to have one, or several visible grade surfaces.

Visible faces need to be protected from the weather, water staining and sun light.

If the Client requires any special or additional weather protection solutions, they should be documented and agreed with Red Stag in advance of placing the order (must be included in the quotation or a signed quoted variation by the Client). It is the responsibility of the Client site team to ensure that extra care is taken when offloading and installing visual panels. Following the installation, the Client must ensure that the visual elements are protected from the weather, natural elements (especially water and light), and physical site damage (prevent installers from marking, getting dirty, moisture, light, impact damage, etc).

43.11 Storage and Care

Red Stag takes reasonable precaution to protect elements while being stored at its site and during transportation. All EWP are susceptible to surface defacement and damage when not properly handled and protected.

43.12 Recommendations for Protection Onsite

- Do not walk on unprotected product or handle the material with soiled hands or equipment.
- Unload trucks and move elements using appropriate lifting equipment. Do not drag, slide, or drop products on the ground, through mud or place on dirty or contaminated surfaces, especially if the products are visual grade.
- Use certified slings and rigging that will not mark the wood.
- Only use chains or cables that have protective blocking or padding to ensure no damage can occur to elements.
- The storage location should allow air movement around panels, but protect from rain, snow, sun, pooled and flowing water, etc. Be sure to have the products suitably elevated off the ground.
- Ensure the products are always covered with good quality tarpaulins or wrap to protect them from moisture, sun/UV damage.
- EWP are susceptible to adverse weather conditions and precautions must be taken to protect them.

43.13 Rain and Cold Weather

It is essential to protect EWP from the rain and snow. If unprotected, rain, snow and moisture will cause staining. If bolts/fixings are used with steel connections, ensure they are free of oil. Oil will cause staining. The use of galvanized bolts and connectors should prevent staining from occurring. Any unprotected steel that can rust, could also transfer oxidisation onto the products and cause staining. Sudden changes in weather can change the moisture content, which can impact the structural integrity of the products.

43.14 Acclimatisation and Stability

Once the structure is airtight, if the moisture content of the EWP is elevated, it is recommended to use dehumidifiers. Options exist to use heat in parallel with dehumidifying, but should only gradually increase the building temperature over a two-to-three-week period up to the standard operating ambient temperature expected for the structure. It is recommended to take a controlled approach to adjusting the moisture content in the superstructure to ensure equalisation with the moisture content in the air. Do not direct any forced air heating systems onto the EWP.

43.15 Exposure to Sun

If an EWP element (or part thereof) has been left uncovered in the sun for a period, a phenomenon called "sun tanning" can occur. Sun tanning is the result of exposing wood fibre to sunlight. Wood fibres will change colour when exposed to direct or indirect sunlight. Sun tanning can result from a tear in the wrap, improperly covering the panel at the project site, or shadowing created by installation aids such as props. It is recommended that EWP are covered with additional waterproof material that is impervious to sunlight. In general, all wood species change colour over time because of exposure to natural light and oxidation of the wood fibres. Over the long term, the colour differences should even out and in most instances and may disappear altogether. If it is deemed necessary, the colour difference can generally be corrected in the short term by manually sanding the affected areas to remove the sun-tanned marks on the EWP elements.

43.16 Hardware Coordination

To facilitate the installation of EWP, Red Stag often supplies ancillary fixings and installation aids. Red Stag carries and extensive portfolio of stocked ancillary items; however, as most are sourced ex-Europe, it is essential that the requirements are scheduled well in advance to prevent delays or additional costs associated with expedited air freight. Red Stag may also coordinate the design and supply of additional bespoke fixings and ancillary items with other suppliers.

The estimated value for fixings provided by Red Stag in the estimates and quotations are a Prime Cost (PC) sum based on a dollar per square meter basis. As soon as Red Stag is provided a precise list of fixings, a firm quotation can be offered.

It is the Client's responsibility to provide Red Stag with a precise quantity survey of all fixings and ancillary items (e.g. installation aids), listing the type and quantity with all applicable specifications.

44.1 Steel Fabrication

Connections between EWP, concrete foundations and steel elements often combine ancillary steel components. Red Stag can collaborate with the Client on an agreed scope for the supply of ancillary steel components. This may include, but not be limited to: base plates and foundation connections, angles, hold-downs, straps, joint plates, other connectors, etc.

44.2 Splines

Some panel-to-panel floor or roof connections might include splines. Subject to the specification, Red Stag may price and supply spline boards. Red Stag does not include splines as a default offering. Client(s) must specifically request the inclusion of splines and the Red Stag quotation must include in the signed quotation to remove any misalignment in supply expectations. If Red Stag supplies splines, it will typically only offer solid timber splines with an average Modulus of Elasticity (MoE) of 8 GPa. Red Stag will only supply splines at a standard length, requiring the construction team to cut to length and manage wastage, etc.

44.3 Glue Laminated Timber and Laminated Veneer Lumber

Many mass timber structures integrate a volume of EWP, including CLT, GLT and LVL. Red Stag can integrate EWP that it manufactures as well as EWP outside of its portfolio, including LVL and GLT. Red Stag can manage the integration process or can work with a nominated manufacturer of the Client's choice (based on mutual agreement). In cases where Red Stag does not manufacture ancillary supply elements, best endeavours will be used to manage the process and associated timeline(s). Supply is subject to the manufacturer's delivery schedule, which may impact the overall project timing, which is outside of Red Stag's control.

The following section outlines suggestions to support the site construction process when building with EWP.

45.1 Site Layout

Prior to the assembly of any panels, it is essential that the construction team and project managers confirm that the gridlines throughout the site are correct and accurate. Ensuring that the foundation layout accuracy is vitally important for the continuity, stability and performance of the mass timber building. Tolerances in mass timber buildings are significantly greater than that of concrete and often steel structures. Ensuring a perfectly flat and level surface is critical. When preparing to installed EWP on concrete, the connection plane must be measured and packed in advance to ensure the plane is level. All wall, floor and roof system tolerances and dimensions must be within 1-2 mm.

45.2 Climatic Conditions

Avoid assembling a mass timber structure in inclement weather. Heavy rain will result in the saturation of the EWP. Equally, as timber is a comparably lightweight material, high winds can impact safe crane and panel assembly operations.

45.3 Installing Panels in Sequence

The panel sequence will have been agreed with the Client project team, and Red Stag shop drawing team prior to manufacturing and despatch to site. The sequence will be matched with the supporting installation programme, truck loading drawings and element label(s).

45.4 Starting Point

It is highly likely that the detailed design of the building will provide specific architectural/engineering specifications for the way panels are to be installed. Ensure that the sequence of the panels, members and elements is in accordance with the design details.

45.5 EWP Foundation Fixing

Wall panels and columns are typically fixed to the foundation slab. Frequently, steel fixings (internal, plate or angle brackets) are used to affix EWP to the foundation. The use of plastic packing shims or plates (heavy duty) should be used to ensure walls are level and plumb. It is essential that installers consult with the design details to ensure that additional inclusions, such as: mastics, acoustic seals, or moisture control devices/applications are correctly applied in sequence as required.

45.6 Propping

The bearing of the structure (vertical and horizontal loads) is achieved predominantly by temporary support(s). Temporary supports assist the construction and assembly process by providing tension relief, preventing collapse of elements, while preserving the vertical structural elements from creep, and partial load transfer to other vertical structural elements. All propping (vertical and horizontal) must be carried out in accordance with the engineer's temporary works program with suitably rated equipment (Red Stag stocks Rothoblaas EWP propping solutions and associated element assembly tools, which can be supplied with ancillaries if required by Clients). The engineer's temporary bracing/propping specification should include the location, angle, connection solution, specification for the propping device(s), and the point/sequence at which the props can be removed.

45.7 Connections

All fixing and connection details are to be followed in accordance with the project engineer and fixing manufacturer's specifications. All connections must be installed using the specified fixings, at the correct location(s), and follow the specified mode of installation defined by the manufacturer.

45.8 Mechanical, Electrical and Plumbing Services

Mechanical, Electrical, and Plumbing (MEP) services will be specified and detailed by the relevant engineering on the project. Where details have been provided, and the manufacturing team have made provisions for MEP, these shall be detailed on the shop drawings for each element (typically via penetrations only). Additional onsite tracing, penetrations, and installation services may need to be carried out to meet the requirements of the project specification.

Section 6

Red Stag
Warranty Statement

Make it better

Red Stag Project Guide V1.0
August 2022

RED STAG®
WOOD SOLUTIONS

46. Warranty Overview

46.1. Unless otherwise specified in the Quotation, Red Stag Wood Solutions Limited (Red Stag) warrants the products manufactured by Red Stag ("Warranted Products") against faulty materials or workmanship for a period of 12 months from the earlier of either the original scheduled delivery date or the date of delivery of the products to the Client ("Warranty").

46.2. The Client shall inspect the Warranted Products as soon as reasonably practicable following the products being ready for dispatch or directly following the delivery of the Warranted Products.

46.3. Any claim by the Customer that the Warranted Products do not conform with the Warranty (or such warranty as otherwise specified in the quotation) shall be made promptly upon discovery of the alleged fault within the warranty period specified in clause 46.1 (or such warranty period as otherwise specified in the quotation). No warranty claim by the Client will be considered or allowed unless it is made in accordance with this clause 46.3.

46.4. On receipt of a warranty claim from the Client in accordance with clause 46.3, the Client shall give Red Stag a reasonable opportunity to inspect any Warranted Products that the Client considers to be faulty.

46.5. If Red Stag accepts that a Warranted Product is faulty following receipt of a warranty claim from the Client in accordance with clause 46.3, Red Stag may, at its sole discretion, elect to:

46.5.1. Repair or replace the Warranted Product (faulty elements only); or

46.5.2. Refund the price of the Warranted Product (faulty elements only) to the Client.

46.6. Any express warranty given by Red Stag to the Client in writing which applies to a product, applies only where the product has been used in accordance with accepted building practices and any other written instructions or guidelines available (refer to the Red Stag literature and supporting web site) or provided by Red Stag before or at the time of the delivery or scheduled delivery, including without limitation the instructions set out at clause 46.47.1 (Warranty: Storage & Handling).

47. Warranty: Storage & Handling

47.1. No express warranty given by Red Stag to the Client in writing will apply to any product that is not used or stored in an appropriate manner. In particular, the Client acknowledges that:

47.1.1. The product must not be dropped or have any impact greater than the design characteristics during transportation, site works, storage or installation at any time, or be loaded to more than 70 percent of its design load prior to the adhesive reaching its full cure and strength.

47.1.2. The product must be stored at least 300 mm above the ground, with no pooled or flowing water (under normal conditions or during a rain event) under the stored area at any time.

47.1.3. Wrap or coverings to protect the product from moisture or direct sunlight during storage shall be kept in place and free from damage (no penetrations to let moisture or sun through) until the last practicable opportunity before the product is incorporated in the structure.

47.1.4. Providing adequate weather protection, and any wrap or covering opened or removed for inspection on delivery shall be re-secured immediately.

47.1.5. If products are supplied with a temporary protection sealer or coating, the Client shall ensure that exposure to the weather does not exceed the limits imposed by the specifications of the sealer or coating.

47.1.6. Where products which have been treated with a timber preservative equivalent to H3.1 or above as part of the manufacturing specification or are cut, drilled or checked on site, they should be managed by the Client to ensure that the applicable areas based on the design requirement for exposure to moisture are appropriately re-treated with a preservative appropriate to the hazard class as required.

This document supersedes all previous versions of Red Stag's Durability Statement, making previous versions obsolete.

Section 7

Red Stag Durability Statement

Make it better

Red Stag Project Guide V1.0
August 2022

RED STAG®
WOOD SOLUTIONS

48. Overview

This Durability Statement is provided by Red Stag Wood Solutions Limited (Red Stag) in support of Red Stag's Cross Laminated Timber (CLT) and Glue Laminated Timber (GLT) use as structural building components within New Zealand. This durability statement covers Red Stag CLT and GLT installed in the following locations as defined in NZS 3602:2003 Table 1A as updated by the New Zealand Building Code (NZBC) B2/AS1 amendment 10 to meet a 50 year durability performance:

- Where not exposed to weather or ground atmosphere, but with a risk of moisture penetration conducive to decay (Ref 1D14, exterior walls).
- Where not exposed to weather or ground atmosphere and in dry conditions (Ref 1E2 mid-floors and ceilings, 1E5 internal walls, 1E7 interior flooring).

49. Product Description

Red Stag Engineered Wood Products (EWP), including CLT and GLT are produced using New Zealand grown Radiata Pine. The Radiata feedstock is graded, treated and verified by Red Stag's timber supplier, Red Stag Timber Limited. Red Stag Timber is the most advanced, and largest structural sawmill in the southern hemisphere. Red Stag Timber's structural timber is verified by third party auditing. Red Stag Timber complete the following processes to verify all EWP feedstock (timber) supplied to Red Stag is fit for purpose:

- Acoustically grade to define an average Modulus of Elasticity (MoE) for each packet.
- Treat timber feedstock to clear boron H1.2 or H3.2 CCA to conform with the NZS3640 standard.
- Re-dry treated timber to and average moisture content of 14 ± 2%.

49.1 CLT:

Lamella (boards) are consolidated to form layers that are faced glued under pressure using Polyurethane Reactive (PUR) adhesive with each layer running perpendicular to the previous.

49.2 GLT:

Lamella are consolidated to form layers that are faced glued using Polyurethane Reactive (PUR) adhesive with each layer running in parallel, in a traditional and bricked format.

50. Structural Timber Grades & Treatment

CLT timber feedstock is typically graded to ensure that all layers running in the same direction as the face layers have an average MoE of 8 GPa and the perpendicular core layers typically have an average MoE of 6 GPa or higher. GLT timber feedstock typically has an average MoE of 8 GPa or higher throughout.

Red Stag produces structural CLT and GLT products using feedstock treated to H1.2 and H3.2 in compliance with the requirements of AS/NZS 1604.1:2021 *Preservative-treated wood-based products* and NZS 3640:2003 A5 *Chemical Preservation of Round and Sawn Timber*.

Each lamella is treated to the requirements defined in NZS 3640:2003 A5 *Chemical Preservation of Round and Sawn Timber* by Red Stag Timber for both retention and penetration. The third-party auditor is Independent Verification Services (IVS).

51. Adhesive

The primary adhesive used in Red Stag's CLT and GLT manufacturing processes is Henkel Purbond HB S-Line. Purbond HB is a one component liquid formaldehyde-free, solvent-free, odourless, moisture-curing, inert adhesive with a polyurethane binder. Purbond was developed in Europe in the 1980's specifically for the EWP sector and is the dominant adhesive in the global manufacture of EWP.

Purbond HB S-Line has been fully tested to establish compliance with all requirements of AS/NZS 4364, and Purbond guarantees that Purbond adhesives are reliable and safe for bonding EWP being used in all service conditions including Service Class 3. The full Purbond Durability statement is available upon request.

The Henkel guarantee extends to all glue lines between the CLT panels, GLT members, and Finger Joints (FJ) that Red Stag manufacturer. Red Stag does expect the wood to check somewhat due to changes in moisture content, but this will not impair the structural integrity, or durability of Red Stag's products.

52. NZBC: CLT Design and Integration

The use of CLT in New Zealand is currently only permitted under the Alternative Solution provisions of the New Zealand Building Act. Until such time as CLT is included in a New Zealand Standard, or a CodeMark is established, building consents will only be issued on a case-by-case basis.

There are no applicable Acceptable Solutions under the New Zealand Building Code (NZBC) Compliance Document B1: Structure (Document Amendment 11). Design to meet the requirements of NZBC B1 is therefore substantiated by specific design in accordance with B1/VM1 and AS/NZS1170, accompanied by a Design Producer Statement by a registered engineer.

Being just an assembly of treated wood and glue, the manufacture of Red Stag CLT complies with relevant provisions of the existing AS/NZS Standards applicable to other solid wood and EWP already covered by the NZ Building Code under:

- NZS 3640:2003 Chemical Preservation of Round and Sawn Timber.
- AS/NZS 1604.1:2021 Preservative-Treated Wood-Based Products - Part 1: Products and Treatment.
- AS/NZS 1604.5: 2002 Specification for Preservative Treatment.
- NZS 3602:2003 Timber and Wood Based Products for use in Building.
- AS/NZS 1491:1996 Finger Jointed Structural Timber.
- AS/NZS 4063.1:2010 – Characterisation of Structural Timber.
- NZS 3603:1993 Timber Structures: This Standard applies specifically to Glue Laminated Timber as well as sawn timber, natural round timber and construction plywood. It sets out requirements for methods of design of timber elements of buildings and is approved as a verification method for NZBC compliance.

As at the publishing date of this document, there are no New Zealand or Australian standards specific to the manufacture of CLT; however, CLT is very similar to GLT in that it is manufactured from treated, FJ, dried timber using glue lamination under pressure. The case for approval as an Alternative Solution under the NZBC can therefore be supported by reference to the following Adopted Standards which govern the preparation, FJ, planing, lamination and verification of GLT:

- AS/NZS 1328.:1998 Glue Laminated Timber Parts 1 & 2; Part 1 covers the performance requirements for GLT and the minimum requirements at the time of manufacture. Part 2 provides guidelines for the manufacture, qualification testing and production control of GLT.
- AS/NZS 4364:2010 Bond Performance of Structural Adhesives.
- NZS 3631:1998 New Zealand Timber Grading Rules.
- AS/NZS 1748:2006 Mechanical Stress Grading of Timber, as modified by NZS 3622:2004.
- AS/NZS 1748:1997 Product Requirements for Mechanically Stress Graded Timber.
- NZS 3622:2004 Verification of Timber Properties.

Red Stag GLT is manufactured using a slightly different process to GLT covered under AS/NZS 1328:1998; however, performance testing has confirmed that the laminating performance and Modulus of Rupture (MoR) meets or exceed the standard for the grades of GLT being manufactured by Red Stag.

Red Stag GLT conforms to the following:

- AS/NZS 1328:1998 Glue Laminated Timber Parts 1 & 2 [vi]. Part 1 covers the performance requirements for Glulam and the minimum requirements at the time of manufacture. Part 2 provides guidelines for the manufacture, qualification testing and production control of GLT.
- AS/NZS 4364:2010 Bond Performance of Structural Adhesives.
- NZS 3631:1998 New Zealand Timber Grading Rules.
- AS/NZS 1748:2006 Mechanical Stress Grading of Timber, as modified by NZS 3622:2004.
- AS/NZS 1748:1997 Product Requirements for Mechanically Stress Graded Timber.
- NZS 3622:2004 Verification of Timber Properties.

[vi] Exceptions to the standard: Aligned adhesive curing pressure to CLT, board configuration, and stepped board configuration overlap ratio. Performance testing confirms the GLT system performance adheres to the standards.

55. Red Stag's Quality Assurance

Red Stag has developed a Quality Assurance (QA) framework including, but not limited to the following aspects of production:

- Health and Safety.
- Raw Material Management: Grading, Treatment, Drying, Stock Control.
- Product Durability.
- Lamella Grading, FJ, Gauging.
- Laminating.
- Panel Machining and Finishing.
- Quality Testing.
- Site Protection and Installation.
- FSC® Management as Required.
- Carbon Management as Required.

Red Stag has invested in a state-of-the-art laboratory to provide all verifiable testing of FJ, and lamination performance of its EWP. Red Stag's QA programme is also supported by third party testing from its adhesive supplier and other third-party certified testing agencies. In parallel, Red Stag has developed comprehensive Management Systems (MS) to control all aspects of its production and operations, and no less than biannual third-party verification testing.

Section 8

Red Stag Assembly Tools

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56. GIRAFFE Prop Overview

A GIRAFFE propping solution has been specifically designed for supporting mass timber wall systems during the construction sequence.

The GIRAFFE propping system is lighter and more easily adjusted than traditional equivalents to simplify and expedite wall and floor system assemblies. Refer to *Figure 82* and *Table 13* for details. The GIRAFFE system comes in three meter and six meter configurations. Further details of GIRAFFE props are summarised in *Table 14*. In wall applications the GIRRAFE system provides angled bracing support and in floor applications acts similar to an Acrow-prop. *Figure 83a to Figure 83d* illustrate examples of GIRAFFE prop applications in CLT projects [19].

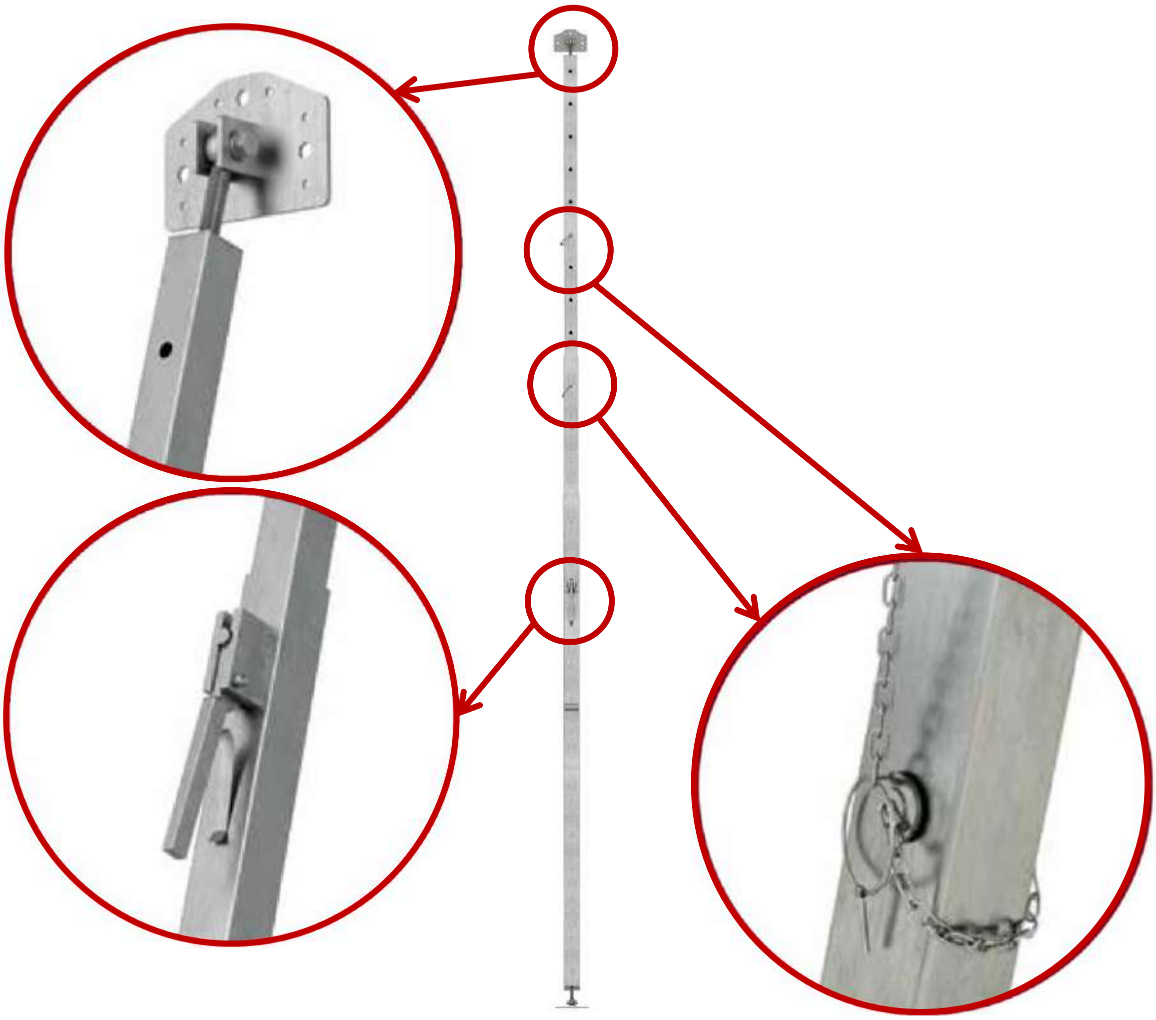


Figure 82: Components of a GIRAFFE prop [19].

Table 13: GIRAFFE Prop Characteristics [19]	
Types	GIR2200, GIR3000, GIR4000, GIR6000
Application	Temporary assembly support
Length	2.2 m to 6.0 m
Load Capacity	Up to 20 kN
Required fixing for GIRAFFE assemb	HBS PLATE Ø10 and SKR Ø12
Material	GIR3000 & GIR4000 in zinc plated steel and GIR2200 & GIR6000 in aluminium.

Table 14: GIRAFFE Props, Dimensions and Weights [19]		
GIRAFFE Type	Length (m)	Weight (kg)
GIR2200	1.18 m to 2.2 m	3.35
GIR3000	1.75 m to 3.0 m	9.80
GIR4000	1.75 m to 4.0 m	13.0
GIR6000	2.12 m to 6.0 m	27.0
Note: GIR6000 acts as a practical and safe support to be used even in case of distant elements extending up to two storeys.		

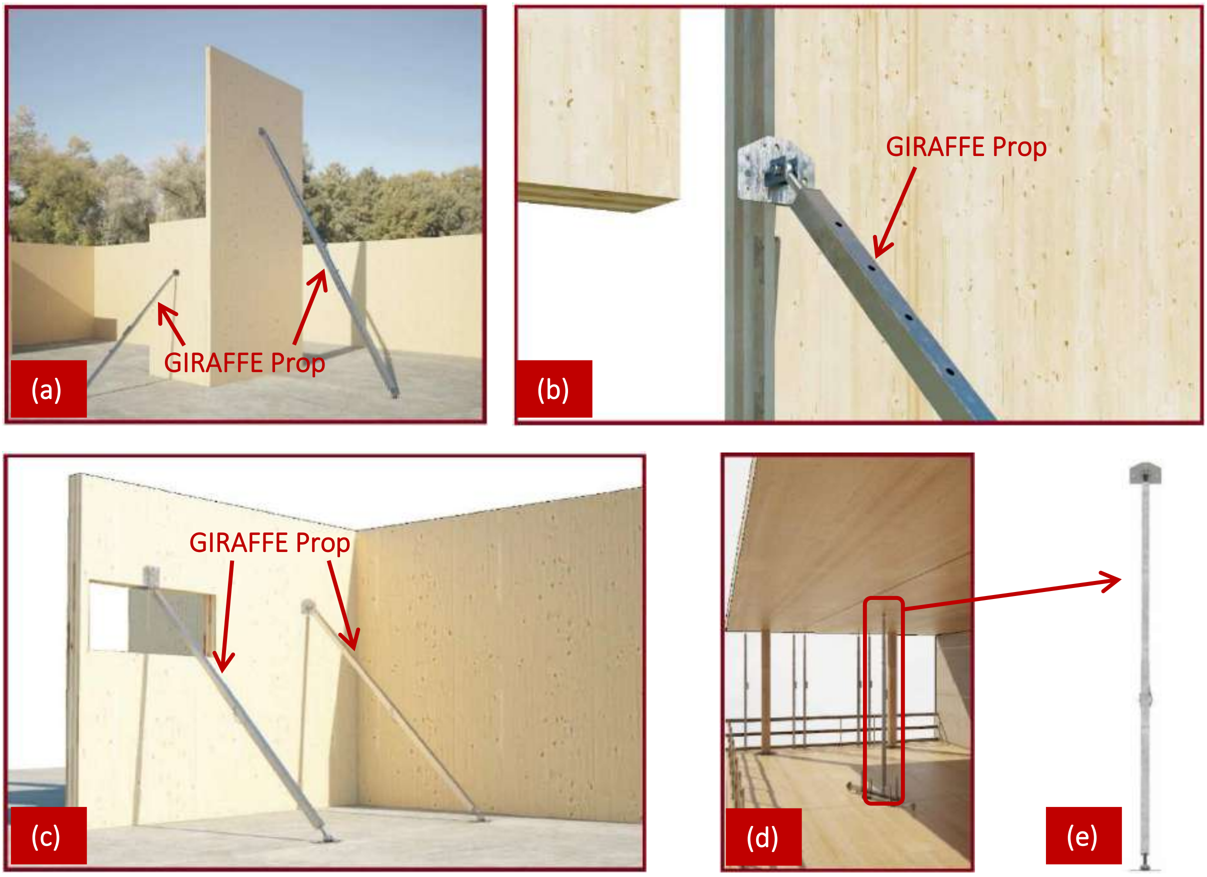


Figure 83: GIRAFFE prop applications in CLT projects; a) GIRAFFE prop for CLT wall installation; b) Application of GIRAFFE prop for wall to wall alignment; c) Application of GIRAFFE prop for wall alignment with opening: d) GIRAFFE prop being utilised in an Acrow prop application for CLT floor support; e) Example of a GIRAFFE prop [19].

56.1 Wall Assembly and Installation

In wall support applications, GIRAFFE props should be installed in the upper third of the CLT wall panel. The angle of the GIRAFFE must be between 30° and 60°. The GIRAFFE fixing plates should be connected to the CLT using Rothoblaas HBS plate screws. If the GIRAFFE is to be connected to a concrete floor system, Rothoblaas SKR anchors should be used. The length of the GIRAFFE is adjustable via the adjustment handle (refer to *Figure 84a* to *Figure 84d*) [19].

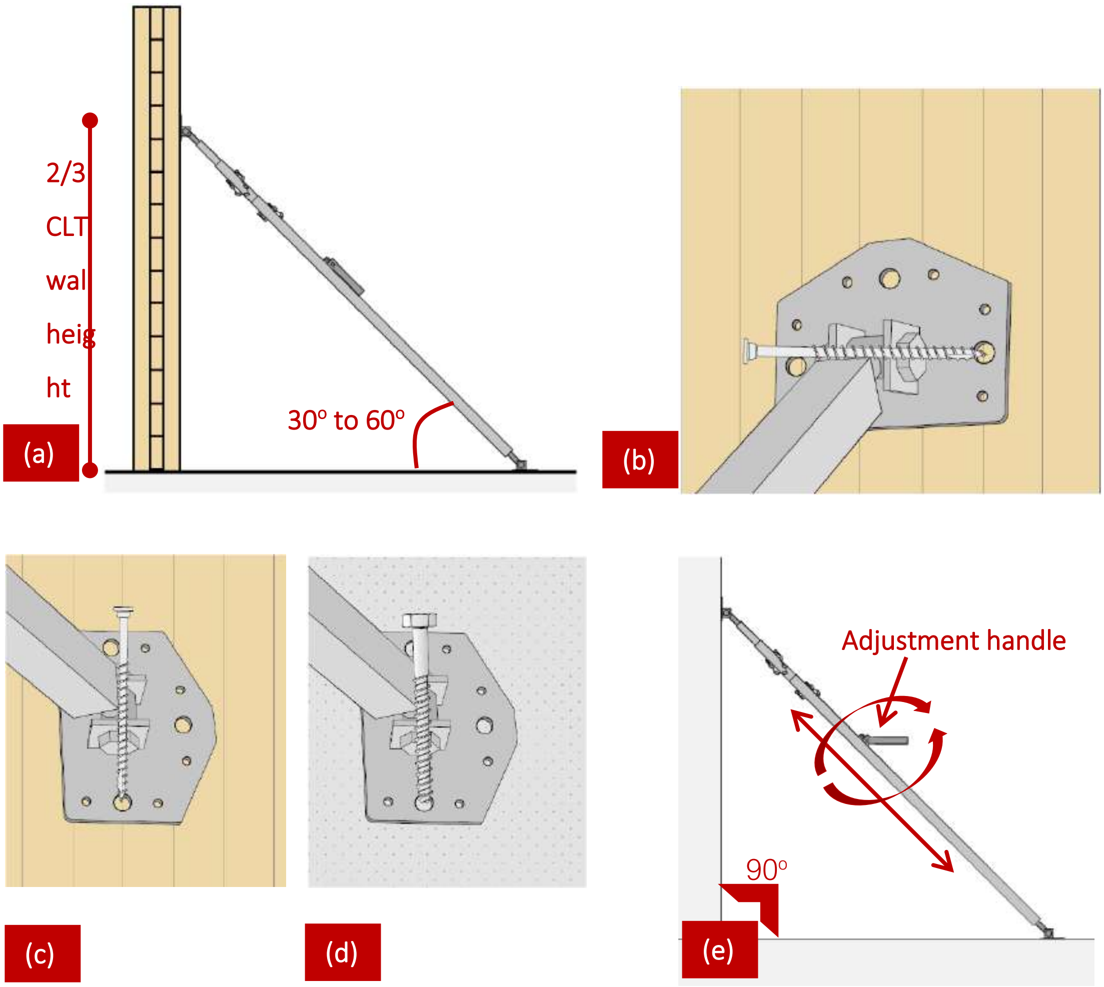


Figure 84: GIRAFFE prop installation process; a) GIRAFFE prop for CLT wall installation in the upper third of the CLT wall at an angle between 30° to 60°; b) GIRAFFE prop connection to CLT wall; c) GIRAFFE prop connection to CLT or concrete floor; d) GIRAFFE prop length adjustment [19].

The fixing solution to connect the GIRAFFE plate to the wall or floor is dependent on the function of the elements that need to be supported. The GIRAFFE type and load to be sustained will determine the fixing requirement (refer to *Figure 85*). The basic loads that need to be consider in selecting the GIRAFFE prop and fixing solution are: wind load, all other lateral loads, all gravity loads (refer to *Figure 86*) [19].

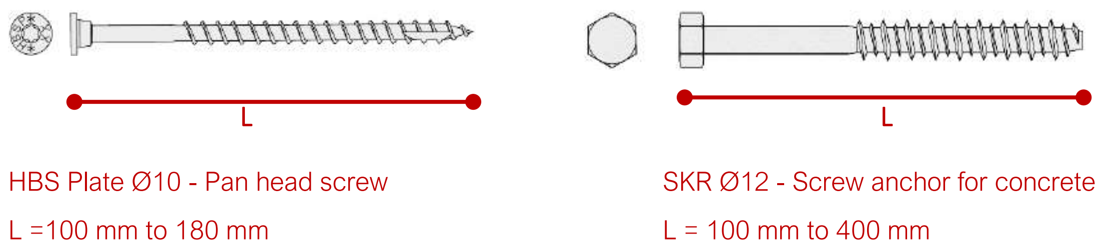


Figure 85: GIRAFFE prop installation [19].

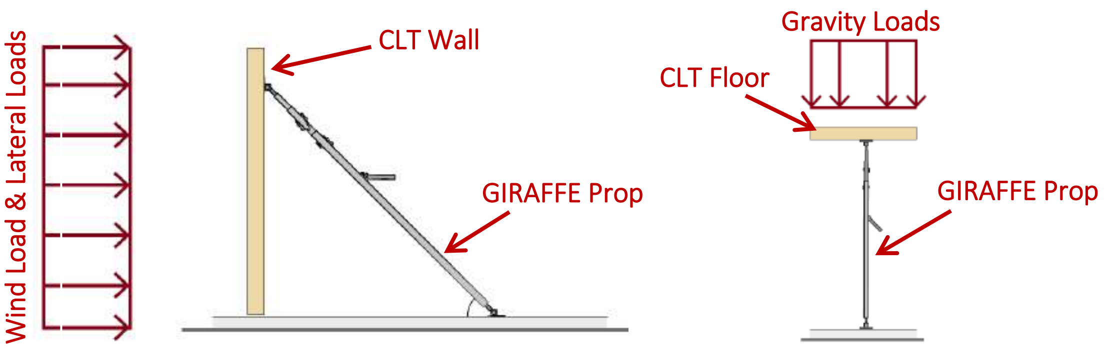


Figure 86: Loadings that need to be consider for GIRAFFE prop calculation [19].

57. SKORPIO Overview

SKORPIO is a custom designed tool to support in quickly and easily pulling larger, heavier EWP members together. The SKORPIO has robust cast hooks, designed to be hammered into the EWP surface. A ratchet mechanism provides an effortless solution to easily pull large, heavy elements together by one installer (refer to *Figure 87*). A SKORPIO can be used for assisting the installation of EWP walls, floor, roof, and beams (refer to *Figure 88*) [20].

Figure 87: Components of a SKORPIO; a) Hammered in hook at each end; b) Reversible ratchet with sturdy fine thread to allow for fine adjustment [20].

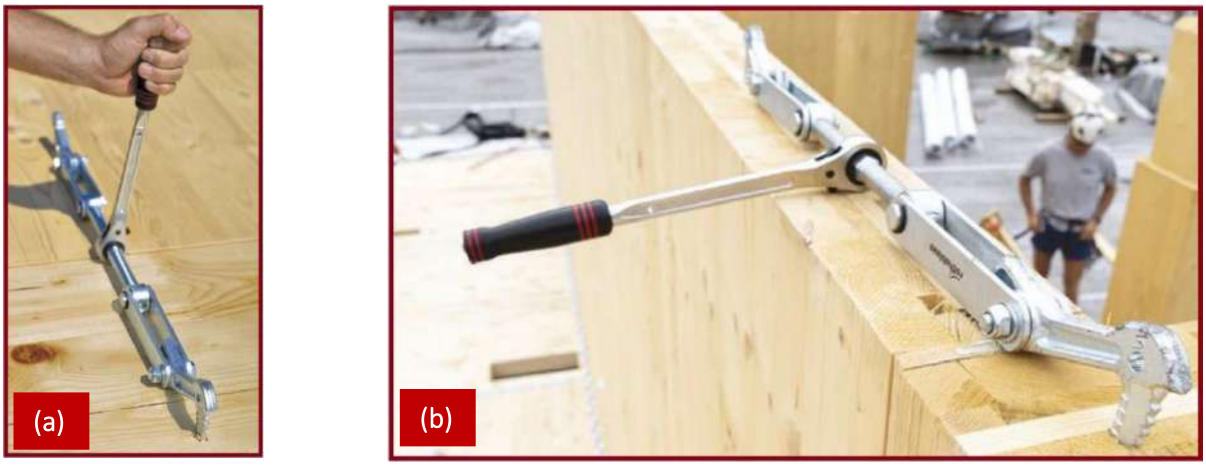


Figure 88: SKORPIO applications; a) SKORPIO utilised to pull CLT floor panels together; b) SKORPIO utilised to pull CLT wall panels together (pulling into a corner) [20].

58. GEKO Overview

Similar to the SKORPIO, the GEKO is a screw fixed ratchet EWP pulling system. The GEKO functions the same as the SKORPIO, but the connection interface is via screwed plates. Typically a GEKO is used to minimise panel damage during the installation process as compared to the SKORPIO (refer to *Figure 89* and *Figure 90*).

Figure 89: Components of a GEKO; a) Steel Plates at each end; b) Reversible ratchet with sturdy fine thread to allow for fine adjustment [21].

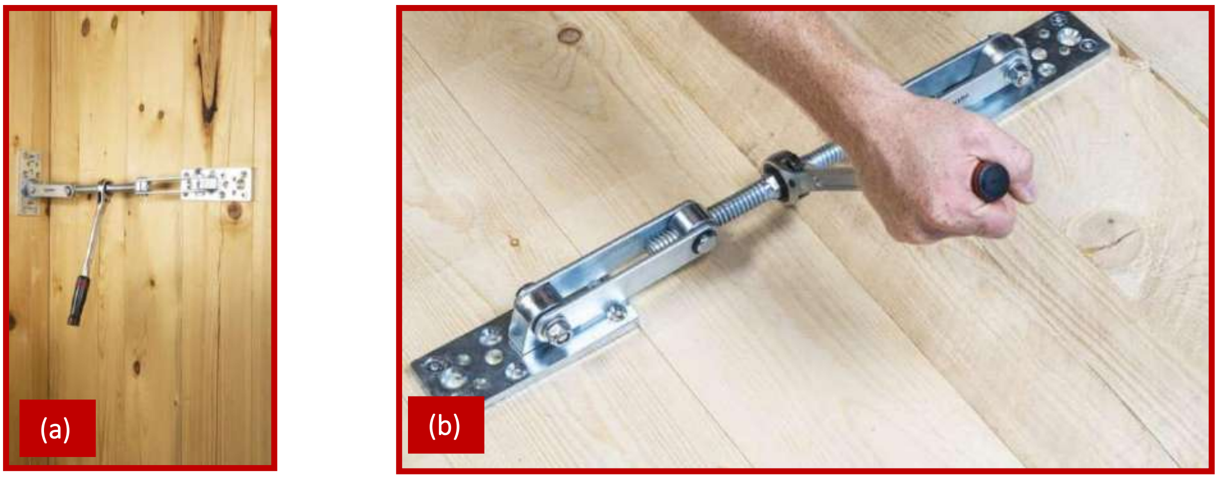
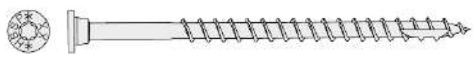


Figure 90: GEKO applications; a) GEKO utilised to pull CLT wall panels together (pulling into a corner); b) GEKO utilised to pull CLT floor panels together [21].

The fixing solution to connect the GEKO plate to the wall or floor is dependent on the hole sizes on the GEKO plate. The GEKO application type and tensile force will determine the fixing requirements [21].



HBS Plate Ø6 – Pan head screw

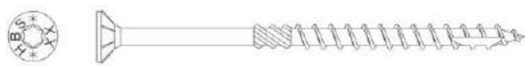
Location: Hole 4,5

HBS Plate Ø10 – Pan head screw

Location: Hole 6

LBS Ø7 – Round head screw

Location: Hole 1,3,4,5,7,8,10,11

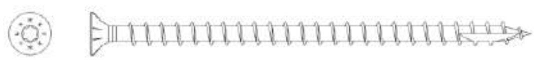


HBS Ø6, Ø8 – Countersunk Screw

Location: Hole 1,3,7,8,10,11

HBS Ø10, Ø12 – Countersunk Screw

Location: Hole 2,9



VGS Ø11 – Fully Threaded Screw

Location: Hole 2,9

Figure 91: GEKO fixing requirements [21].

Appendix & References

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August 2022

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WOOD SOLUTIONS

By signing this document, you are confirming that you are authorised to do so on behalf of the Client and acknowledge that the project files submitted for shop drawings associated with the project are accurate, finalised, consented and ready for the shop drawing process to commence. It is confirmed that all project consultants have reviewed the project files and there are no conflicts within the documents. Red Stag takes no responsibility for the accuracy and/or completeness of the drawings and models provided by the Client.

Once the Client issues a drawing and CAD package to allow Red Stag to commence the shop drawing process, if there are any changes that could affect the Red Stag shop drawing process, it is responsibility of Client/project consultants to update Red Stag with clearly identified and highlighted changes as soon as practically possible.

Any changes to the drawings or re-work required by Red Stag as a consequence of changes in drawings provided by the Client will result in additional shop drawing charges and may require an extension to the shop drawing and associated supply programme timeline from Red Stag (refer to *Section 1 – Shop Drawing Guide* of the *Red Stag Project Guide)*. Additional charges will be based on the additional time required to complete the process(es) at the latest rates defined in the Red Stag documentation at the time of the change(s).

The shop drawing pricing is based on a maximum of two revisions. More than two revisions will incur additional costs to the Client based on time and may impact the programme schedule. The Client will not be adversely impacted for any additional revisions due to errors or omissions by Red Stag in not actioning clear revision notes supplied by the Client/Project consultants.

The Client/Project Consultants understand that the shop drawing process will only commence following:

1. The Red Stag quotation being signed by the Client with a mutually agreed project timeline and counter signed by Red Stag.
2. The project deposit being paid in full as defined in the quotation.
3. All documents being received as defined in *Section 1* (Requirements) of the Red Stag Shop Drawing Guide.

The Client authorised representative will ensure that the Client project team confirm every aspect of the shop drawings and sign off that they are dimensionally correct, and all design properties are correct and in line with the project's requirements. Red Stag takes no liability for any omissions or errors in the shop drawings. The Red Stag manufacturing process with follow the shop drawings within the allowable tolerances.

Any delay on any part of the shop drawing process by the Client may lead to delays in the process and associated project delivery. Please refer to *Section 1 – Shop Drawing Guide* of the *Red Stag Project Guide* for all details.

Project Details:

Project Name: ....

Red Stag Job Number: ....

Client authorised representative contact details: ....

Authorised to submit drawings, coordinate on RFI, manage the shop drawing review process, sign off on shop drawings:

Clients Representative Name: ....

Clients Representative Email: ....

Clients Representative Mobile: ....

Architectural Shop Drawing Submission Details:

Job Name: ....

Job Number: ....

Drawing Set Revision Details:..

Drawing Date: ....

Structural Shop Drawing Submission Details:

Job Name: ....

Job Number: ....

Drawing Set Revision Details:..

Drawing Date: ....

Appendix B: Project Shop Drawing Approval Form

By signing this document, you acknowledge that the Shop Drawings for the project are approved in their entirety, are accurate and reflect all project requirements, you are authorised by the Client to sign off and that you accept that the project can immediately commence manufacturing by Red Stag at its discretion.

Signing this form confirms that the Client's/Authorised Client Consultant(s) accept that all details specified in the shop drawings, including but not limited to: thickness, dimensions, panel recipe, laminations, grain directions, grades, treatments, penetrations, cutting/processing requirements, and all related tolerances of the drawn elements [vii] are correct for the entire project. It is also acknowledged and agreed that the manufacturing process cannot commence or have the production schedule finalised until this document is signed and returned to Red Stag without any amendments unless countersigned by a Red Stag authorised signatory. Please refer to *Section 1 – Shop Drawing Guide* of the *Red Stag Project Guide* for all details.

The Client accepts all additional charges if Red Stag is required to make any changes or is required to re-work any part of the shop drawings or manufactured/processed elements [viii] . Shop drawing charges will be applied at the defined hourly rates. Manufacturing re-work will be charged at the applicable rates at the time of the required re-work processing. Changes or rework to either the shop drawings or manufacturing/processing will impact the project timeline. Delays are generally not linear as they are subject to resource and production availability.

Project Details:

Project Name: ....

Red Stag Job Number: ....

Project Address: ....

Shop Drawing Revision Number: ....

Shop Drawing Submission Date: ....

Shop Drawing Page Numbers: ....

Client Authorised Representative Acceptance:

As the Client authorised signatory, I agree and accept that the project team have reviewed all shop drawings comprehensively and agree to all details in this document and the *Red Stag Project Guide* to allow for the project to commence manufacture at Red Stag's discretion.

Signature of Authorised Signatory: ....

Date of Signing: ....

Name of Authorised Signatory: ....

Title of Authorised Signatory: ....

Employing Company of Authorised Signatory: ....

[vii] Elements include but are not limited to: Cross Laminated Timber (CLT) components, Glue Laminated Timber (GLT) components, light timber framing, trusses, connection details and fixings, any other modelled component/element, etc.

Appendix C: Project Lifting & Scheduling Approval Form

By signing this document, you are confirming that you are authorised to do so on behalf of the Client. You acknowledge that the Panel Lifting Points drawing package, and the Truck Loading Schedule for the project are accurate, reflect all project requirements, and are accepted in their entirety, including the lifting solution, which you confirm has been signed off by the project engineer and project installation team. The Client accepts that Red Stag is not accountable for any technical information or specification referenced in any lifting points document or any other technical data sheet associated with the Rothoblaas screws or lifting system(s). Please refer to the *Red Stag Project Guide* for all details.

By signing this letter, the Client accepts that the project can immediately commence manufacturing by Red Stag at its discretion.

Signing this letter confirms that the Client/Client Authorised Consultant(s) accept that all details specified in the Panel Lifting Points drawing package, and the Truck Loading Schedule for all elements [vii] are accepted. It is also acknowledged and agreed that the final production schedule cannot be finalised until this document is signed and returned to Red Stag without any amendments unless countersigned by a Red Stag authorised signatory.

The Client accepts all additional charges if Red Stag is required to make any changes or is required to re-work any part of the project or manufactured/processed elements following the signing of this document [vii]. Shop drawing charges will be applied at the defined hourly rates. Manufacturing re-work will be charged at the applicable rates at the time of the required re-work processing. Changes or rework to either the shop drawings or manufacturing/processing will impact the project timeline. Delays are generally not linear as they are subject to resource and production availability.

Project Details:

Project Name: ....

Red Stag Job Number: ....

Project Address: ....

Shop Drawing Revision Number: ....

Shop Drawing Submission Date: ....

Shop Drawing Page Numbers: ....

Client Authorised Representative Acceptance:

As the Client authorised signatory, I agree and accept that the project team have reviewed all shop drawings comprehensively and agree to all details in this document to allow for the project to commence manufacture at Red Stag's discretion.

Signature of Authorised Signatory: ....

Date of Signing: ....

Name of Authorised Signatory: ....

Title of Authorised Signatory: ....

Employing Company of Authorised Signatory: ....

pass™ PRODUCT ASSURANCE SUPPLIER STATEMENT

pass™ no: 19168 | Expires: 12/2022

RED STAG WOOD SOLUTIONS

RED STAG® CROSS LAMINATED TIMBER

PURPOSE

Red Stag® Wood Solutions Limited supplies Cross Laminated Timber (CLT) for use in mass timber construction.

EXPLANATION

Red Stag® CLT is manufactured in New Zealand from New Zealand grown Radiata Pine.

Red Stag® Timber Limited grades and treats the feedstock with H1.2 (boron treatment) or H3.2 (CCA treatment) at the Waipa Mill Road site as follows:

- To AS/NZS 1748:2011 to meet characteristic values as required by Red Stag® Wood Solutions
- To NZS 3640:2003 to exceed the minimum requirements stated in tables by 6.1 and 6.2 of the standard.

From the graded and treated feedstock, Red Stag® Wood Solutions Limited manufactures Red Stag® CLT. Red Stag® CLT generally comprises 3 to 11 layers, has a thickness of 60 to 420 mm and meets the following material strength characteristics.

Structural Properties	Longitudinal Laminates	Transverse Laminates
Modulus of Elasticity (MoE)	8 GPa	6 GPa
Bending Strength	14 MPa	10 MPa
Compression parallel to the grain	18 MPa	15 MPa
Compression perpendicular to the grain	8.9 MPa	8.9 MPa
Tension shear	6 MPa	4 MPa
Nominal shear	3.8 MPa	3.8 MPa

For further assistance please contact:

+64 7 843 5797

ewp@redstag.co.nz

www.redstag.co.nz

WE COMPLY s14G BUILDING ACT 2004

Red Stag® Wood Solutions Limited uses Red Stag® CLT to produce prefabricated:

- Stairs
- Roof, ceiling, wall and floor panels
- Structural systems, that use Red Stag CLT® combined with other members, e.g. floor systems
- Beams.

Reg Stag Wood Solutions provides a project specific PS3 where applicable.

SCOPE AND LIMITATIONS OF USE

Scope	Limitations
Location	
In any wind design ULS.	The design and specification of Red Stag® CLT is subject to specific engineering design.
In any exposure zone as defined in NZS 3604:2011.	Where microclimatic conditions apply as set out in paragraph 4.2.4 of NZS 3604:2011, contact Red Stag® Wood Solutions Limited for advice.
In all seismic zones.	
In all snow loading zones.	
Any proximity to a relevant or notional boundary.	Where located within 1 m of a relevant or notional boundary the specification of Red Stag® CLT is subject to specific fire engineering.
Building	
In conjunction with the balance of the primary structure that complies with the New Zealand Building Code or for an existing building where the specifying engineer has determined that the existing building is suitable for the intended building work	
As a wall panel in a building of any building height.	Where the building height exceeds 10 m and there are sleeping uses or other property in upper storeys, the specification of Red Stag® CLT is subject to specific fire engineering. Subject to specific engineering to NSZ 3603:1993 or similar.
As roof, ceiling, wall and floor panels.	Where material group number obligations or fire related structural stability applies, the specification of Red Stag® CLT is subject to specific fire engineering. Subject to specific engineering to NSZ 3603:1993 or similar.
As part of an acoustic and/or fire rated wall, floor or ceiling system.	Subject to specific engineering to NSZ 3603:1993 or similar.
As beams.	Subject to specific engineering to NSZ 3603:1993 or similar.
As prefabricated stairs.	Subject to specific engineering to NSZ 3603:1993 or similar.

USEFUL INFORMATION

For information on the design, installation and maintenance of Red Stag® CLT refer to **www.redstag.co.nz**.

OTHER CERTIFICATIONS AND APPROVALS HELD BY RED STAG® TIMBER LTD

- FSC. [01/03/2019]. (Single Chain of Custody and Controlled Wood Certificate). Certificate codes NC-COC-003967, NC-CW-003967, RA-COC-003967, RACw_003967
- ISO 14001:2015. Lumber processing & manufacturing. Global Compliance Solutions cert. no. 854E6

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PERFORMANCE CLAIMS

If designed, installed and maintained in accordance with all Red Stag® Wood Solutions Limited requirements, Red Stag® CLT will comply with or contribute to compliance with the following performance claims:

NZ Building Code clauses	BASIS OF COMPLIANCE	
	Compliance statement	Demonstrated by
B1 STRUCTURE B1.3.1 B1.3.2 B1.3.3 (a, b, c, f, l, j, m, q) B1.3.4 (a, b, d, e)	Verification method B1/VM1	› Tested for bending strength to AS/NZS 4063:2010 and EN 16351:2015 (E). [Scion, 27/06/2019]. › Red Stag verification testing [November 2021].
B2 DURABILITY B2.3.1 (a) B2.3.2 (a)	ACCEPTABLE SOLUTION B2/AS1	› Feedstock treated to NZS 3640:2003. Audited and tested in accordance with IVS Treatment Assurance Programme [IVS, 24/06/2021; 29/11/2021, 08/12/2021].
C6 STRUCTURAL STABILITY C6.2 C6.3	VERIFICATION METHOD	› Expert assessment of expected structural fire capacity of Red Stag® CLT floors [Enovate, 29/07/2021; 20/08/2021; Warrington Fire, 03/08/2021].
F2 HAZARDOUS BUILDING MATERIALS F2.3.1	ALTERNATIVE SOLUTION	› Application of NZTPC Best Practice Guideline for the Safe Use of Timber Preservatives & Anti-sapstain Chemicals. › Red Stag® Timber Ltd is part of the IVS Treatment Assurance Programme [IVS, 24/06/2021; 29/11/2021, 08/12/2021]. › Use in accordance with manufacturer's safety requirements.

SOURCES OF INFORMATION

- Enovate. [29/07/2021] *RE: Fire Assessment and Span Tables for RSWS CLT Floors.*
- Enovate. [20/08/2021] *RE: Fire Assessment and Span Tables for 5 layer RSW'S CLT Floors.*
- FSC. [01/03/2019]. (Single Chain of Custody and Controlled Wood Certificate). Certificate codes NC-COC-003967, NC-CW-003967, RA-COC-003967, RA-Cw_003967
- Global Compliance Solutions. [22/07/2020]. ISO 14001:2015. Environmental Management. Lumber processing & manufacturing. Cert. no. 854E6
- IVS. [24/06/2021]. *Audit report: timber preservation.* Report no. J023512.
- IVS. [29/11/2021]. *Timber testing compliance report.* Job reference 59617.
- IVS. [08/12/2021]. *Timber testing compliance report.* Job reference 59791.
- Red Stag® Wood Solutions. [January 2021]. *Cross Laminated Timber Technical Brochure.* V2.4.
- Red Stag® Wood Solutions. [November 2021]. *Verification testing results report.*
- Scion. [27/06/2019]. *Red Stag CLT Bending to AS/NZS 4063:2010 & EN 16351:2015(E).* Job TE18-065.
- Warrington Fire. [3/08/2021]. *Fire assessment report.* Fire resistance performance of loadbearing CLT floors. Report number FAS210211 Revision R1.1.

1. Where a standard is referenced it is to be read as amended by the acceptable solution or verification method as applicable.
2. Sources of information also include the Building Act 2004 and its regulations, including the Building Code (Schedule 1 of the Building Regulations 1992), Acceptable Solutions and Verification Methods, and relevant cited standards.

SCAN OR CLICK THIS QR CODE FOR A FULL DOWNLOAD OF COMPLIANCE DOCUMENTATION FOR THIS PASS™.
www.redstag.co.nz

Red Stag® Wood Solutions Limited confirms that if Red Stag® Cross Laminated Timber (CLT) is used in accordance with the requirements of this pass™ the product will comply with the NZ Building Code and other performance claims set out in this pass™ and the company has met all of its obligations under s14 G of the Building Act.

Date of first issue:	17/12/2021
Date of current issue:	17/12/2021
NZBN:	9429030267459

Kevin Brunton

Kevin Brunton, Technical Director, TBB confirms that this pass has been prepared on behalf of Red Stag® Wood Solutions Limited and in accordance with MBIE PTS guidelines and in accordance with the TBB pass™ process which is within the scope of TBB's ISO 9001 certification.

9606D66ADE51EA6CCC25850D00239F99 global-mark

Waipa State Mill Road, Rotorua › ewp@redstag.co.nz › +64 7 843 5797 › www.redstag.co.nz

VERSION: V1.0

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References

[1] WASP Hook for Timber Elements Transport, Rothoblaas Catalogue. Website Link: https://www.rothoblaas.com/products/machines-and-tools/transport-and-lifting/wasp.

[2] Pro Clima, (online on 2022) Pro Clima Website, Website Link: https://www.proclima.com/

[3] Rothoblaas (online on 2022) Rothoblaas Website, Website Link: https://www.rothoblaas.com/

[4] High-Performance, The Blue Book, Pro Clima, (online on 2022) Pro Clima Website, Website Link: https://proclima.co.nz/building-science-soup/

[5] Clarke, 2020

[6] DIN 68800-2: Wood preservation - Part 2 - Global HIS, (online on 2022) Website Link: https://www.beuth.de/en/standard/din-68800-2/147794351.

[7] ÖNORM B 2320, Dwelling houses made of wood - Technical requirements, (online on 2022) Website Link: https://shop.austrian-standards.at/action/de/public/details/609115/OENORM_B_2320_2017_08_01.

[8] FLA guide

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Contact Details:

Website: redstag.co.nz

General Enquiries & Quotation Requests: ewp@redstag.co.nz

General Accounts & Finance Team Enquires: accounts@redstag.co.nz

Phone: 0800 RED STG (0800 733 784) Office
+64 7 843 5797