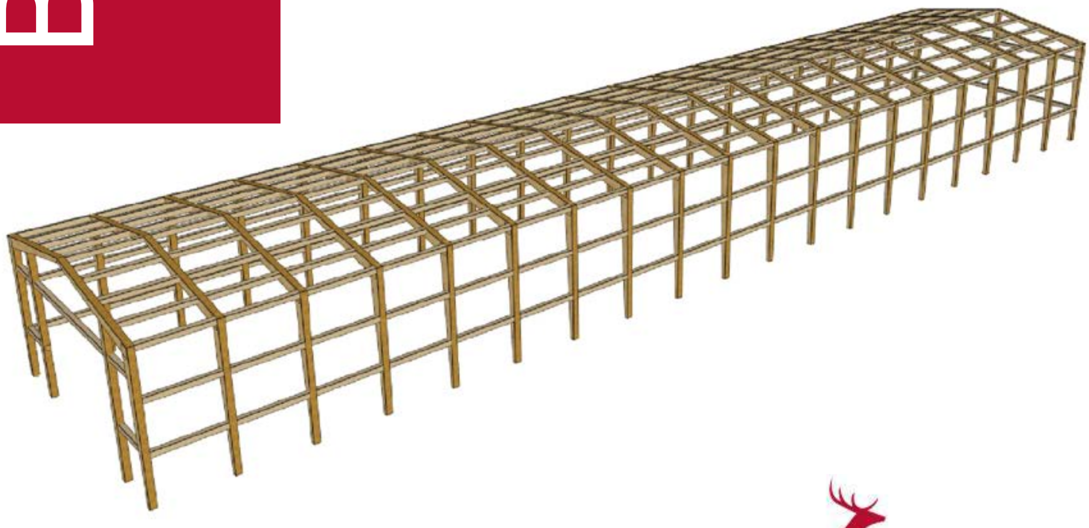
Red Stag CLT Beam Brochure



Make it better

Red Stag CLT Beam Brochure V1.0
February 2023

RED STAG®

1. Overview

Cross Laminated Timber (CLT) beams are a relatively new application for a well proven product. CLT has grown in popularity in the construction sector over the past decade for its speed of installation, reduced mass and environmental benefits. CLT beams are manufactured using the same manufacturing process as any other CLT element (opposing layers glued together 90 degrees out of phase with the previous layer) (refer to *Figure 1*).

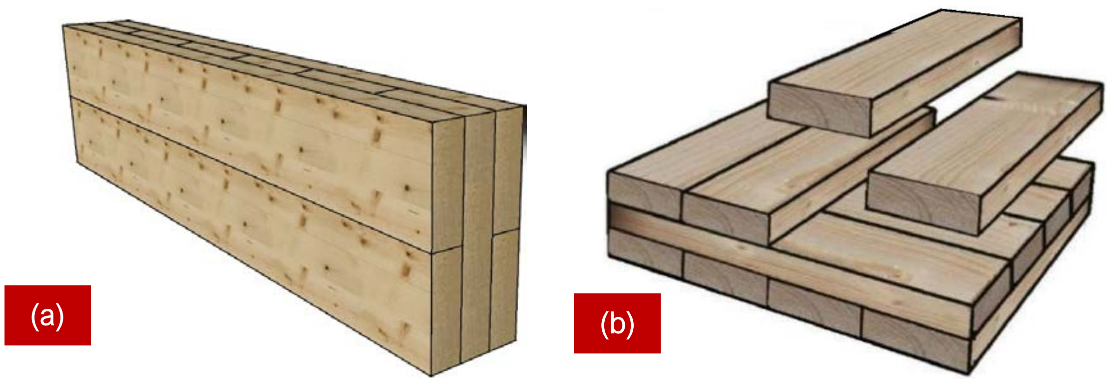


Figure 1: Red Stag CLT beam; a) CLT beam installed orientation; b) Lamella arrangement.

Red Stag CLT consists of a number of graded, treated, kiln-dried laminations, typically 42 mm thick, bonded with structural adhesive.

Red Stag's scale manufacturing facility has the ability to produce CLT billets up to 16.5 x 4.5 x 0.42 m (Length × Width × Depth) for CLT beams. *Figure 2* shows one of three vacuum presses at the Red Stag EWP manufacturing plant in Rotorua.

Figure 2: One of Red Stag's CLT vacuum presses.

The CLT beam's mechanical behaviour differs from traditional CLT applications (i.e. floors and walls). To support in confirming the mechanical performance of CLT in beam applications, Red Stag has completed extensive internally testing via third party calibrated, and certified equipment used for compliance testing. The internal test programme is in addition to comprehensive testing conducted at SCION for the balance of Red Stag CLT.

Ongoing test results confirm the performance and suitability of Red Stag CLT in structural beam applications. Advanced compliance test configurations and equipment are illustrated in *Figure 3*.

Figure 3: Large-scale mechanical testing of Red Stag CLT beam conducted by Red Stag; a) End Elevation; b) Elevation.

CLT beams provide a very high strength-to-weight ratio comparable to concrete. CLT beams are typically no less than five times lighter, reducing the mass loading on building foundations, which is particularly valuable on sites with poor soil conditions.

Tensile strength is a major advantage of CLT beams over GLT. The perpendicular opposing layers create high tensile strength perpendicular to the CLT beam length/span, making the CLT beams less susceptible to rupture (Refer to *Figure 4*).

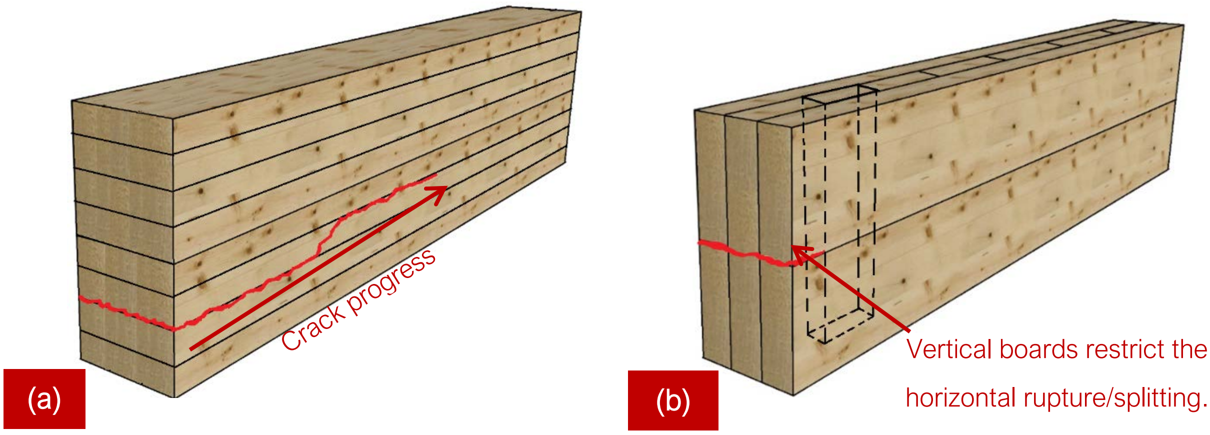


Figure 4: Progressive cracks in beams; a) Traditional GLT beams with continuous progressive rupture; b) CLT beam's perpendicular lamella restrict the rupture from progressing down the span.

CLT beams have superior performance to solid wood for the following reasons:

- Larger knots and defects (Refer to *Figure 5a*) are removed through the remanufacturing process, with shook connected via structural finger joints.
- Laminating generates a uniform, homogenous system, with a higher average structural performance (Refer to *Figure 5c*), with improved stability.

CLT beams have a lower risk of lateral defection compared to structural timber beams due to the fibre layers running in the transverse direction. The risk of lateral deflection increases in deep beams, making CLT beams a superior alternative to GLT in deep formats.

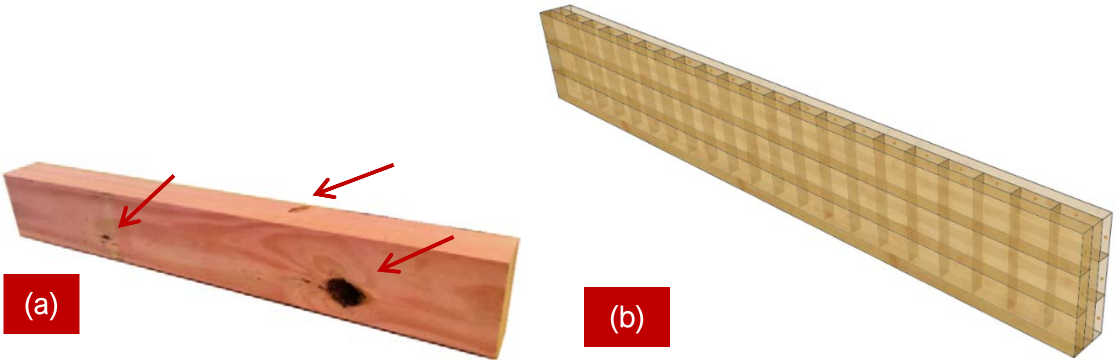
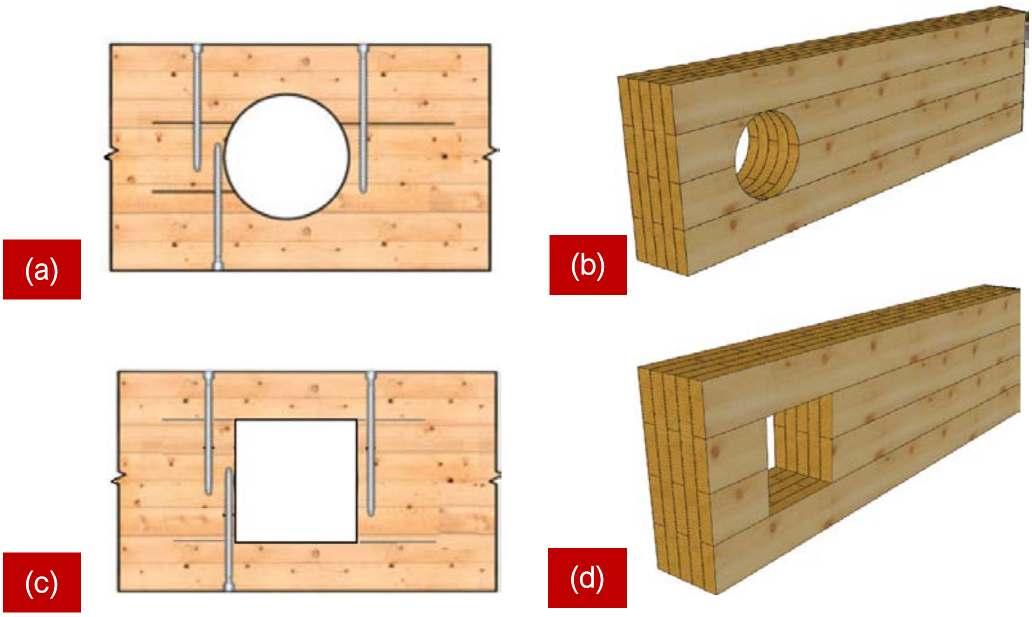


Figure 5: Structural timber beam versus CLT beam; a) Structural timber beam with common defects; b) CLT beam.

The cross-layer configuration of CLT beams reduces the risk of splitting at supports, penetrations, and connections. *Figures 6a* and *6b* compare the additional mechanical fixings required for a circular penetration through GLT versus CLT. *Figures 6c* and *6d* compare the additional mechanical fixings required for a square penetration through GLT versus CLT. CLT beams provide grain to grain support in high compression zones via the transverse layer(s). Refer to *Figures 6e, 6f, 6g* and *6h comparing* the additional mechanical fixings required for load bearing interfaces in higher compression zones. The high-tension capacity in the transverse layers of CLT significantly reduced the risk of splitting in bolt, screw and rivet connections parallel or perpendicular to the grain (Refer to *Figures 6i, 6j, 6k* and *6l*).



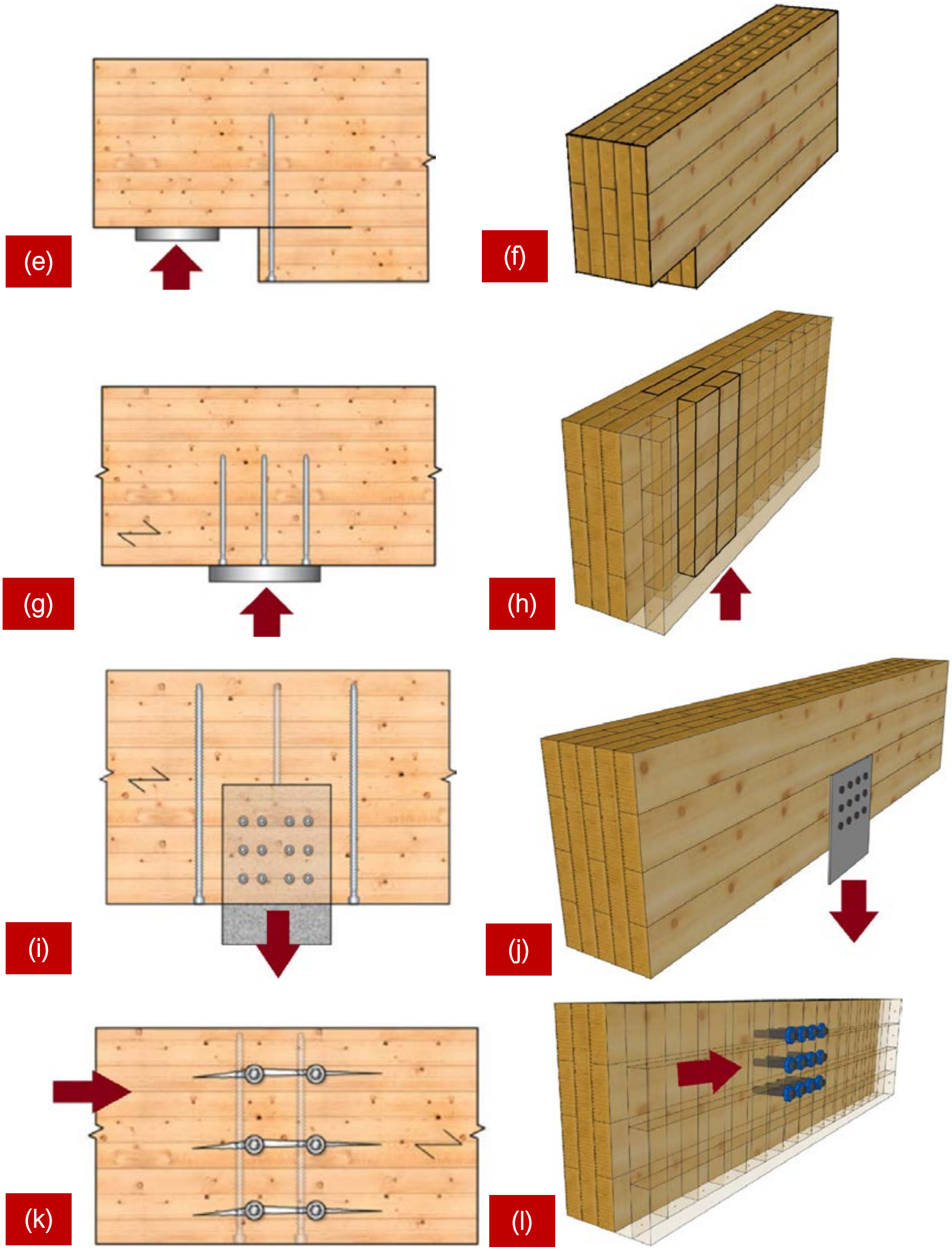


Figure 6: Red Stag CLT beam versus traditional GLT beam configurations; a, b, c, d) Improved reinforcement around openings in Red Stag CLT versus traditional GLT; e, f) Improved reinforcement at notched load interfaces in Red Stag CLT versus traditional GLT; g, h) High compression bearing capacity (grain to grain bearing) in Red Stag CLT versus traditional GLT; i, j, k, l) Improved connection performance parallel or perpendicular to the grain in Red Stag CLT versus traditional GLT.

2. Red Stag CLT Applications

Red Stag CLT beams are suited to a wide range of applications such as lintels, beams, purlins, portal frames, etc.

2.1 Red Stag CLT Portal Beams

Red Stag CLT is a strong, cost-effective structural alternative for portal frame structures. Portal frames are one of the most favoured structural solutions for commercial and industrial buildings whose functions necessitate long spans and open interiors. Red Stag CLT offers designers simplicity, speed and economy in fabrication and erection for portal frame applications.

Red Stag CLT has been tested for portal frame knee connections. The CLT beam to column joint under cycling load has been tested by a third party certified laboratory to confirm the structural performance in a large-scale application (Refer to *Figure 7*).

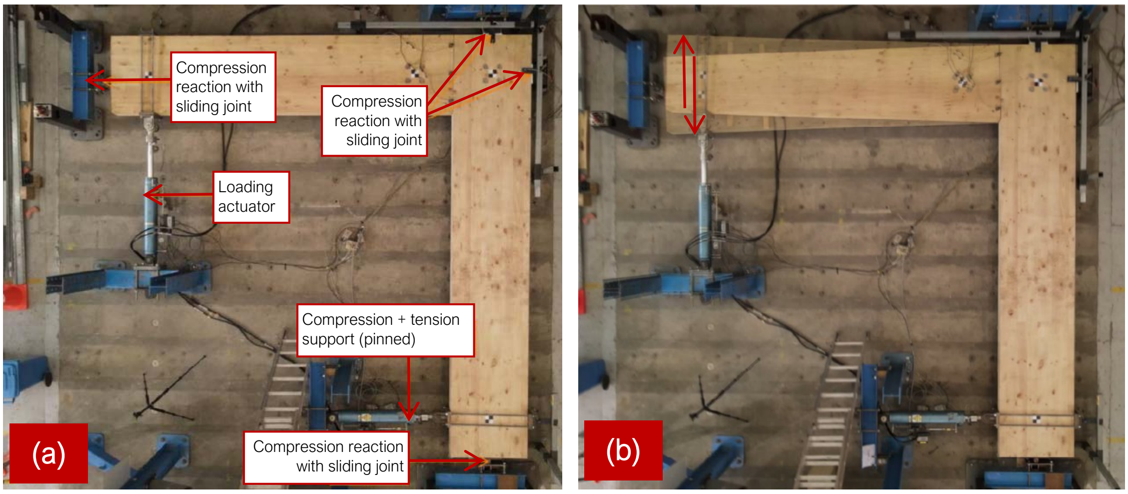


Figure 7: Large scale knee test for portal frame application; a) Red Stag CLT portal frame test setup; b) Red Stag portal frame under cyclic load.

The experimental testing confirmed that design calculation based on the Timber Design Guide 2007 is conservative when compared to the test results.

An important finding from the testing is that the corner reinforcing screws, which are typically required for GLT/LVL frames, are not required for Red Stag CLT Portal Frames.

The load conditions (test cycling) for the test continued beyond the design properties for the portal frame. Testing concluded with the Red Stag CLT performing more than 2.5 times the bending strength of SG8.

CLT portal frames are an excellent environmentally friendly structural option for replacing commonly used steel portal frames. The environmental benefits of timber portal frames can be further improved by converting steel purlins to Red Stag CLT or GLT (Refer to *Figures 8* and 9). The environmental benefit of timber portal frames and purlins, versus the steel and concrete equivalents is presented in *Figure 10*.

According to NS-EN 15804:2012 and BS EN 15804:2012+A2:2019, the core environmental impact indicator for climate change is the Global Warming Potential (GWP). GWP is correlation of sequestered carbon to carbon emissions (kg CO_2-eq). *Figure 12* shows that steel and concrete portal frames have a considerably higher total GWP/m^2 than the timber equivalent.

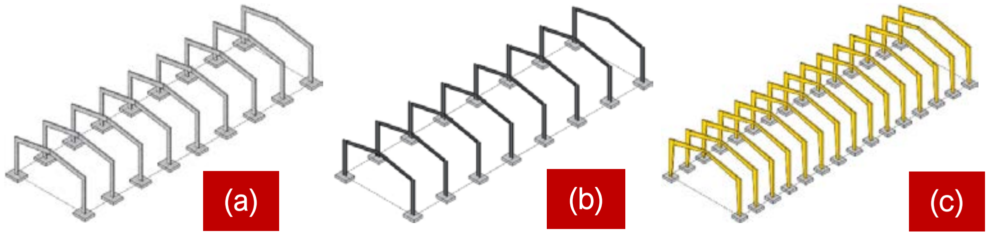


Figure 8: Equivalent representation of portal frame design with steel, concrete and timber; a) Steel portal frame; b) Concrete portal frame; c) Timber portal frame.

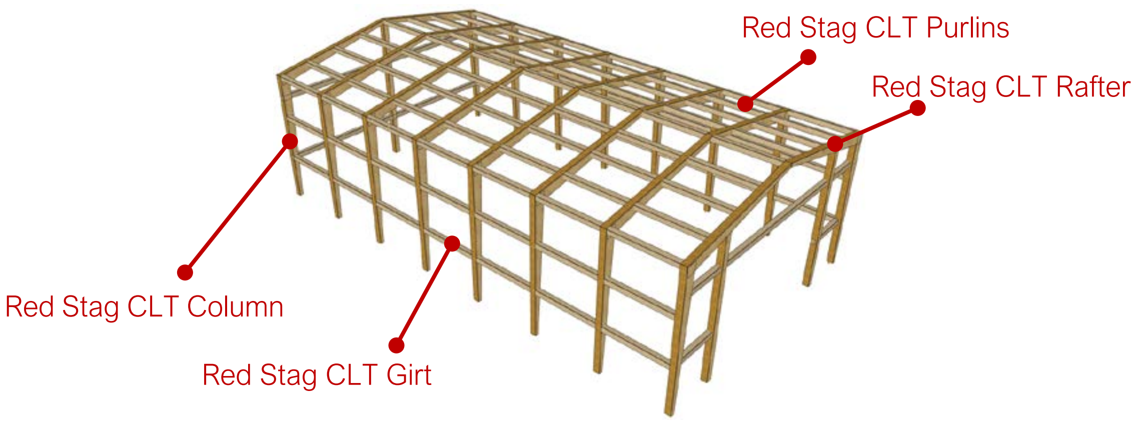


Figure 9: CLT portal frame and CLT purlins.

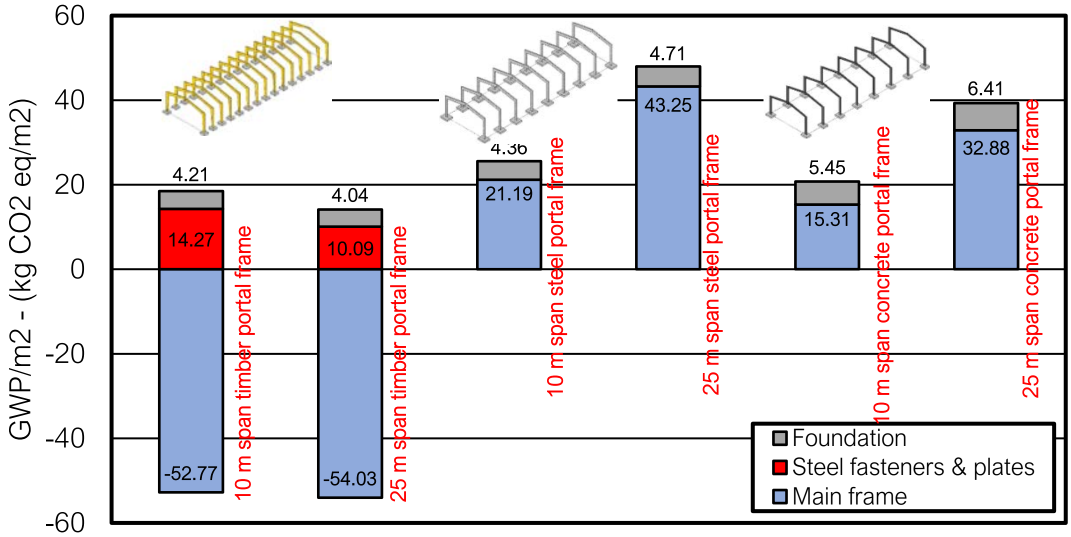


Figure 10: Environmental impact of timber portal frame compared to steel and concrete portal frames.

Depending on engineering design and CNC equipment the CLT portal frame could have less fibre wastage and fabrication time, making it a more cost-effective alternate to other EWP and steel portal frames (Refer to *Figure 11*).

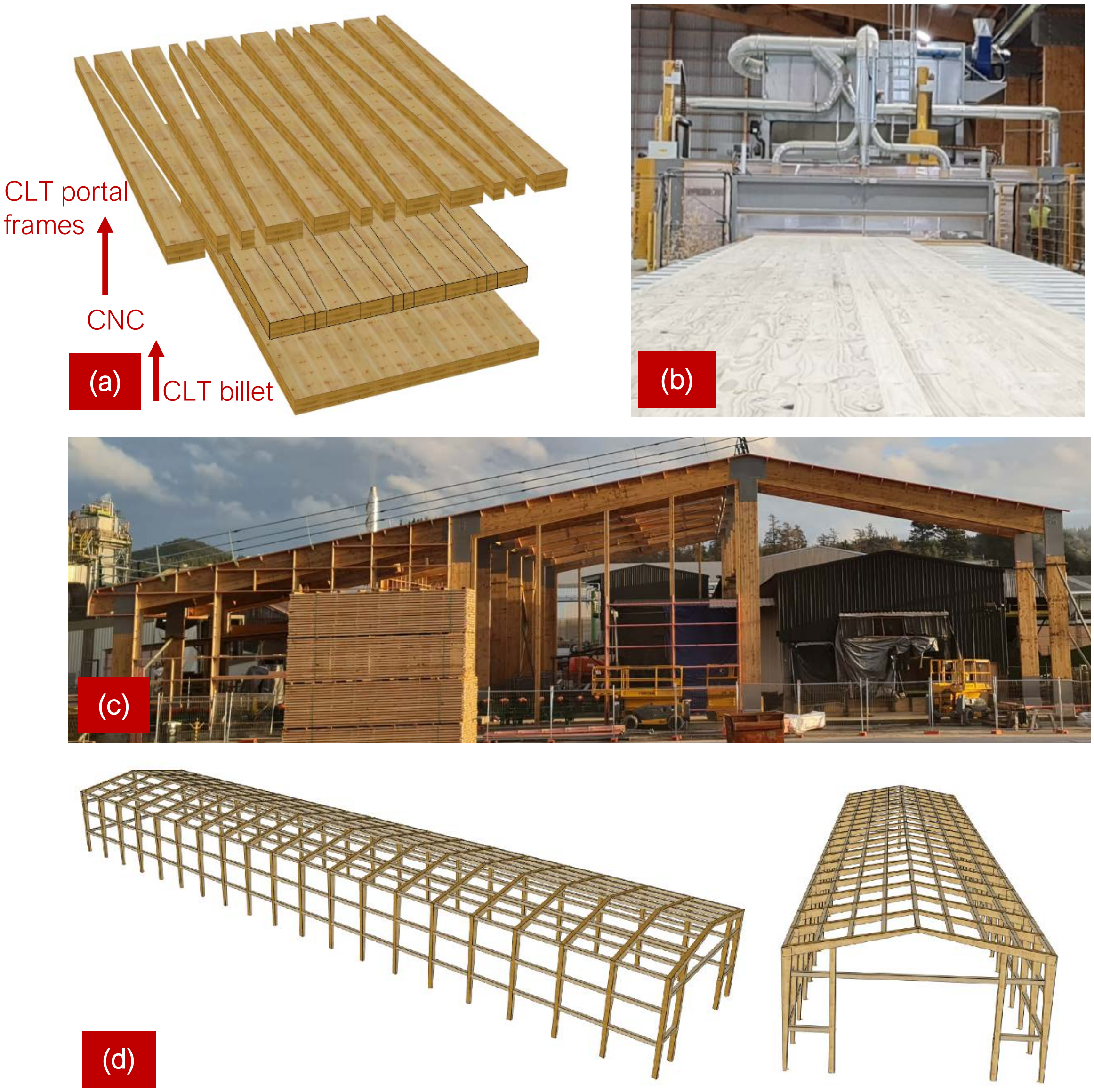


Figure 11: Fast and efficient CNC processing of Red Stag CLT portal frames; a) Optimisation process of CLT portal frame manufacturing; b) Red Stag CNC equipment; c) Parallel CLT portal frame at Red Stag stacker building; d) Truncated CLT Portal frame.

2.2 Red Stag CLT Lintel Beam

Openings in timber frame walls are typically spanned by horizontal structural members known as lintels. Red Stag CLT is structurally suitable for bridge openings such as windows and doors (More common in wider framing; however, Red Stag is targeting 90 mm alternatives as well) (Refer to *Figure 12*).

Figure 12: Red Stag CLT lintel in a Red Stag Wood Solutions frame; a) Red Stag CLT lintel over a window opening; b) Example of a common Red Stag CLT lintel.

Continuous lintel systems have less deflection under similar load conditions (Refer to *Figure 13*) and provide much larger spans or distance between supports as compared to simply supported lintels. The Red Stag CLT lintel properties are summarised in *Table 1*.

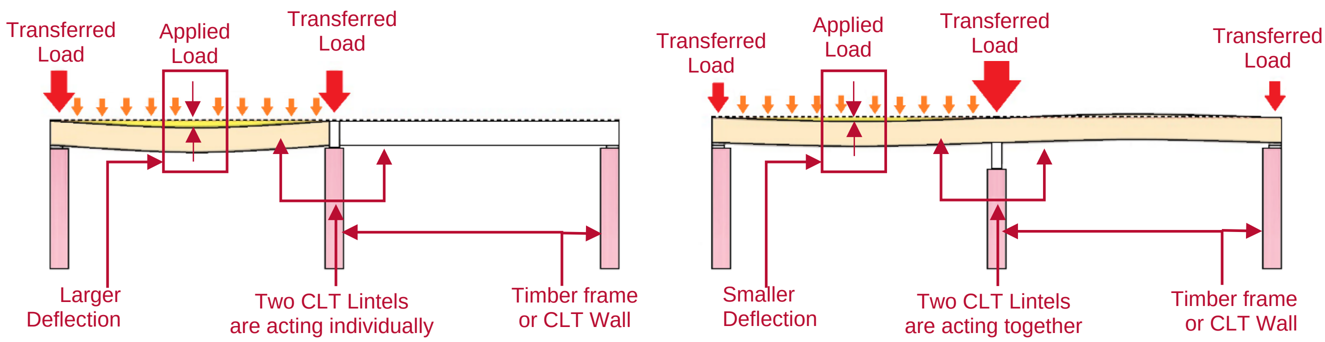


Figure 13: Comparison of deflections between single and double-span CLT lintels to support applied loads.

Table 1: Red Stag CLT Lintel Properties [a, b, c, d]

Depth	Width	I (mm⁴)	EI	Z (mm³)	ØMn long	ØMn med	ØMn short	As mm²	ØVn long	ØVn med	ØVn short
90 mm	126 mm	5103000	40824000	113400	1.24 kN.m	1.65 kN.m	2.07 kN.m	5040	10.7 kN	14.3 kN	17.9 kN
140 mm	126 mm	19208000	153664000	274400	3.00 kN.m	4.00 kN.m	5.01 kN.m	7840	16.7 kN	22.3 kN	27.8 kN
190 mm	126 mm	48013000	384104000	505400	5.53 kN.m	7.37 kN.m	9.22 kN.m	10640	22.7 kN	30.2 kN	37.8 kN

[a] MoE of lamella in longitudinal direction = 8 GPa.
[b] Characteristic of wood planks in longitudinal direction = f_b = 19 MPa and f_s = 3.7 MPa.
[c] Only the capacity of wood plans in longitudinal is considered in the calculation.
[d] Red Stag will verify calculation by the experimental test with the SCION laboratory.

2.3 Red Stag CLT Beam (and Joists)

Red Stag CLT beams provide an alternative to steel or concrete beams to support floor or roof systems in buildings. *Figure 14* represents a Red Stag floor system build up with CLT beams and CLT flooring. The Red Stag CLT beam properties are summarised in *Table 2*.

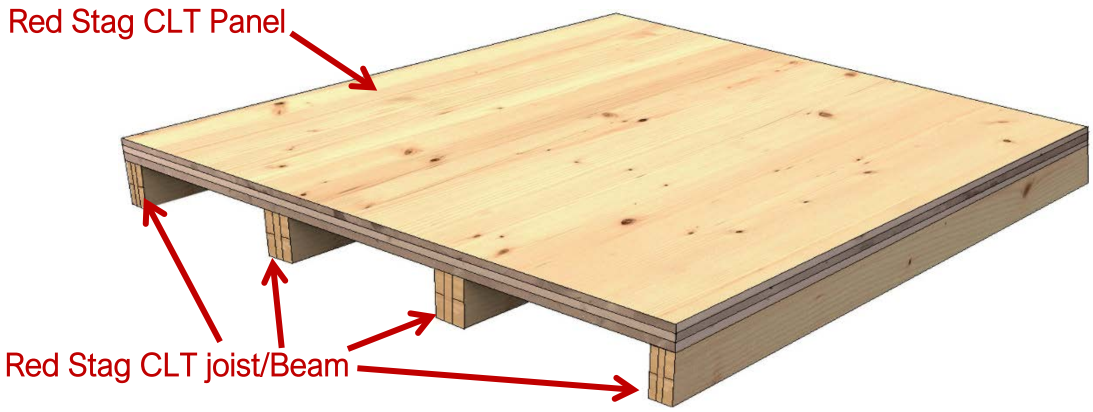


Figure 14: Example of a Red Stag CLT beam and CLT floor system.

Table 2: Red Stag CLT Beam Properties [a, b, c, d]

Depth	Width	I (mm^4)	EI	Z (mm^3)	ØMn$_{long}$	ØMn$_{med}$	ØMn$_{short}$	As mm^2	ØVn$_{long}$	ØVn$_{med}$	ØVn$_{short}$
240 mm	126 mm	96768000	774144000	806400	8.83 kN.m	11.77 kN.m	14.71 kN.m	13440	28.6 kN	38.2 kN	47.7 kN
290 mm	126 mm	170723000	1365784000	1177400	12.89 kN.m	17.18 kN.m	21.48 kN.m	16240	34.6 kN	46.1 kN	57.7 kN
300 mm	126 mm	189000000	1512000000	1260000	13.79 kN.m	18.39 kN.m	22.98 kN.m	16800	35.8 kN	47.7 kN	59.7 kN
240 mm	144 mm	119808000	958464000	998400	10.93 kN.m	14.57 kN.m	18.21 kN.m	16640	35.5 kN	47.3 kN	59.1 kN
290 mm	144 mm	211371333	1690970666	1457733	15.95 kN.m	21.27 kN.m	26.59 kN.m	20106	42.9 kN	57.1 kN	71.4 kN
300 mm	144 mm	234000000	1872000000.	1560000	17.07 kN.m	22.76 kN.m	28.45 kN.m	20800	44.3 kN	59.1 kN	73.9 kN
240 mm	166 mm	145152000	1161216000	1209600	13.24 kN.m	17.65 kN.m	22.06 kN.m	20160	43.0 kN	57.3 kN	71.6 kN
290 mm	166 mm	256084500	2048676000	1766100	19.33 kN.m	25.77 kN.m	32.21 kN.m	24360	51.9 kN	69.2 kN	86.5 kN
300 mm	166 mm	283500000	2268000000	1890000	20.68 kN.m	27.58 kN.m	34.47 kN.m	25200	53.7 kN	71.6 kN	89.5 kN

[a] MoE of lamella in longitudinal direction = 8 GPa.
[b] Characteristic of wood planks in longitudinal direction = f_b = 19 MPa and f_s = 3.7 MPa.
[c] Only the capacity of wood plans in longitudinal is consider in the calculation.
[d] Red Stag will verify the calculation by the experimental test with the SCION laboratory.

3. Routine Quality Performance Testing

Red Stag has a comprehensive Quality Assurance (QA) programme for its manufacturing processes. The Red Stag QA processes utilise one of the most advanced automated EWP test laboratories in the world, in conjunction with detailed Red Stag Standard Operating Procedures (SOP) (Refer to Figure 15). Red Stag has a comprehensive third-party testing and audit programme in addition to its internal testing.

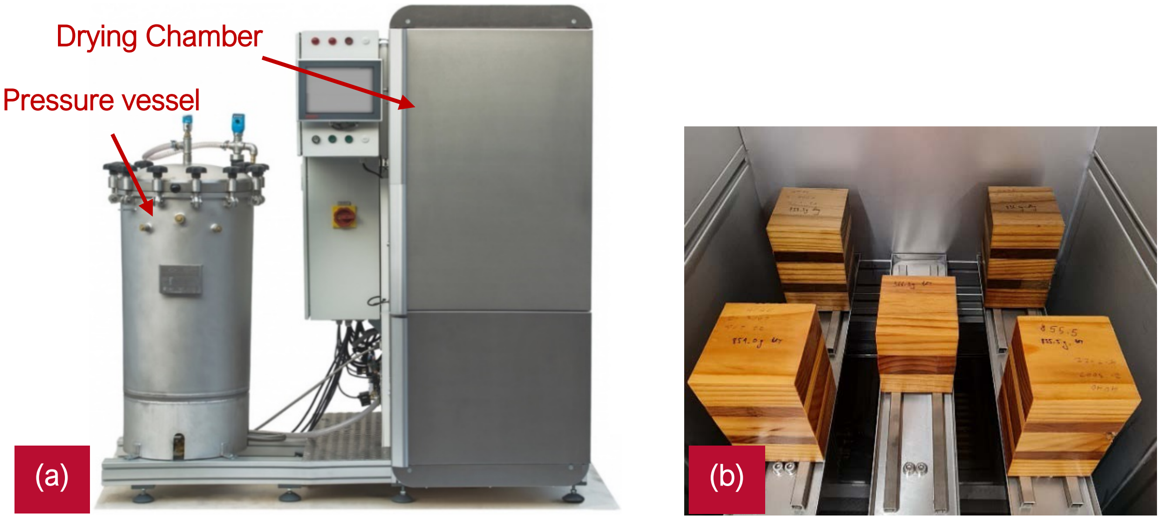


Figure 15: Red Stag CLT quality assurance; a) EWP delamination testing equipment; b) CLT specimens for delamination testing.

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