briefing note 13

Cross Laminated Timber Frames

briefing note contents

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This Briefing Note was produced on behalf of Willmott Dixon by WD Re-Thinking Ltd

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Introduction

In the current market, Willmott Dixon Capital Works are increasingly looking toward Cross Laminated Timber (CLT) frames as an alternative to more traditional structural frame methods such as steel, concrete and masonry.

CLT frames offer a number of advantages including:

- Reduced programme durations;
- Waste minimisation;
- Safer working environments on site, and;
- Improved air tightness.

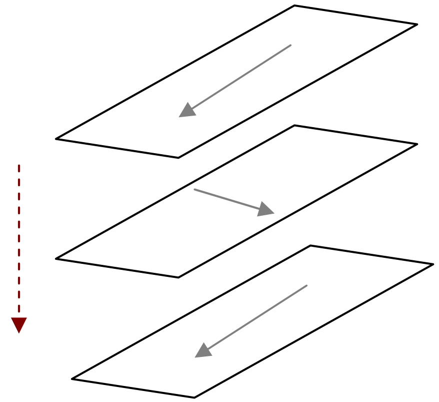
A number of Willmott Dixon Construction projects have been constructed using CLT frames to date, impressing our clients and upholding our image as an innovative, sustainable and responsible contractor.

This briefing note explains what CLT frames are, how to construct them, the standard design details, the key health and safety considerations and the contractors that we use. Case Studies on three Willmott Dixon projects constructed using a CLT Frame system have also been included.

What is Cross Laminated Timber?

Cross Laminated Timber (CLT) panels are produced from mechanically dried spruce boards which are stacked together at right angles and glued over the entirety of their surface. Each CLT panel is produced is between three and seven boards thick depending on the amount of structural loading required.

Gluing at high pressure reduces the timbers expansion and shrinkage potential to a negligible level. The result is a rigid structural timber member that can be used both vertically and horizontally to construct a buildings frame.



A cross laminated timber panel formed of 5 mechanically dried spruce boards.

Construction Method

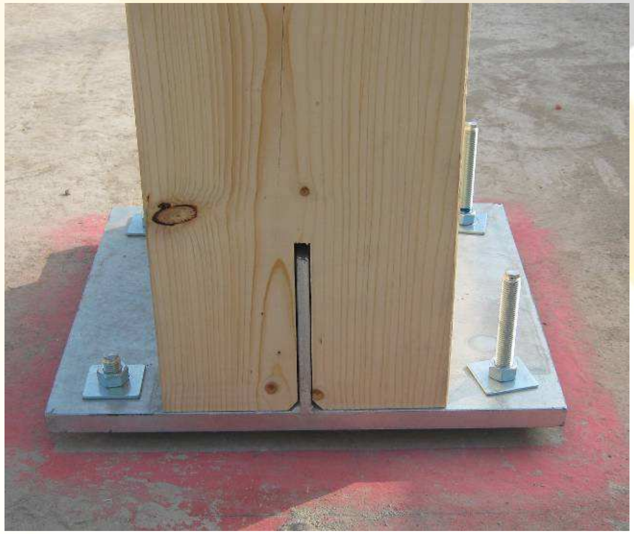
CLT Frames can be quickly erected on site and reduce programme durations considerably when time is invested into their design beforehand.

Initially, Willmott Dixon (typically an appointed sub-contractor) must prepare a concrete ground floor slab for the CLT frame to be erected onto. Usually this must be to a tolerance of +/- 10mm over 5m. The timber frame contractor can level the timber frame on the slab within this tolerance once on site. As with more traditional forms of construction, below slab drainage should be installed beforehand with pipes penetrating the slab (and capped off) as appropriate.

The timber frame contractor then visits site before any timber is delivered to inspect the slab and to set out the ground floor structural walls and partitions.

Once this is complete, DPM strips are laid along the line of the walls for the CLT panels to sit on (below).

Base plates are fixed to the slab and levelled in preparation for the glulam columns (below) and smaller fixing plates are positioned along the line of the walls.



CLT panels are then delivered to site.

Ideally the delivery lorry will park on site and wait whilst each panel is offloaded and fixed into place. This may take up to 8 hours for a typical delivery of 17 panels being offloaded in low winds by a dedicated crane.

It is advisable to ensure that panels are loaded onto lorries by the contractor's supplier in the sequence that they will be required for installation on site.

Where it is not possible to install panels immediately, they can be offloaded and stored off the ground under a water proof tarpaulin until required.

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Glulam columns will be fitted to their base plates first in preparation for the CLT panels (see earlier image).

As CLT panels are lifted into place, they will be guided and fixed by the timber frame contractor's operatives (please read in conjunction with the Health and Safety section contained later in this briefing note). The contractor may install temporary handles onto the timber panels to assist with this process.

Temporary support struts installed to ensure stability during erection.

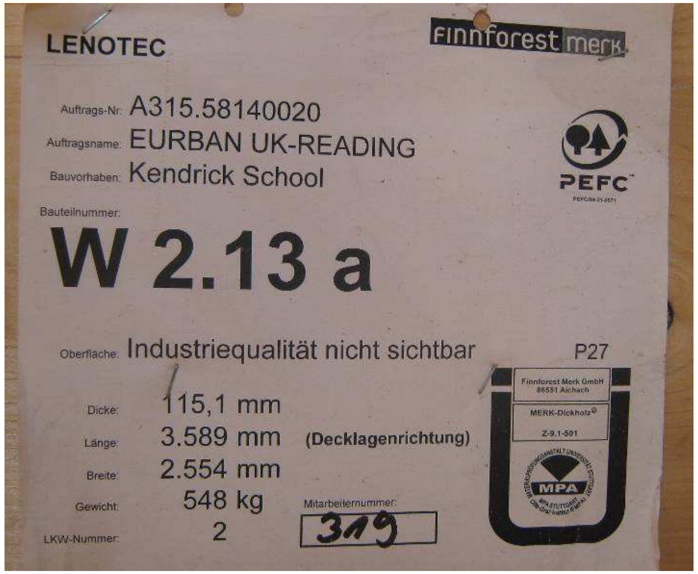
Panel guided into place by trained operatives.

Once a panel is in place, temporary supporting struts will be installed to ensure the panels stability in the interim period whilst the other panels and floor slabs around it are installed and the structure becomes independently stable.

A CLT panel is considered safe once it has been fixed into place and these struts have been fitted.

This process is repeated for the subsequent floors above and for the roof slab.

Each CLT element will be given a unique reference code that relates to the timber frame contractor's design drawings to ensure that each panel is installed in the correct place (below).

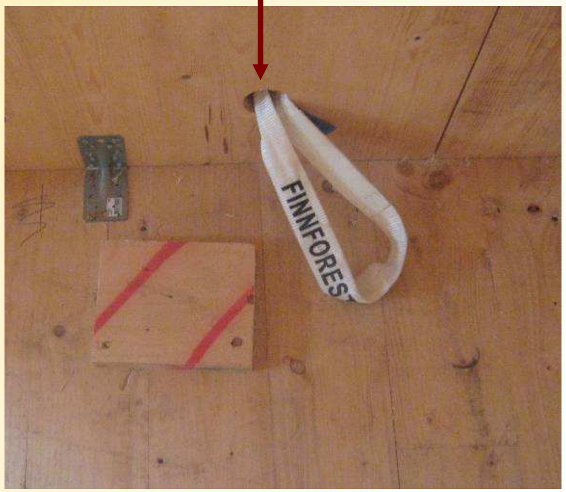


CLT panels may arrive on site with pre-installed lifting strops. Each should be certified and labelled (below).

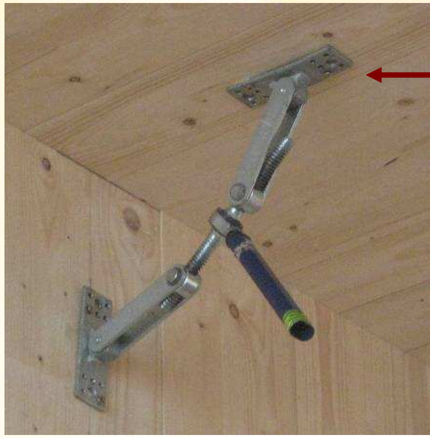
Once a panel is in place, the pre-installed lifting strop should be rolled up, put inside the anchor hole and then taped over. This enables the building to be deconstructed in the future (note each lifting strop would have to be re-tested before it was re-used).

Each individual pre-installed lifting strop should be certified.

Pre-installed lifting strops can be rolled up, placed back inside the anchor hole and taped over for future use (after testing).



To ensure a tight fitting between timber elements the timber frame contractor may use a tightener. This is essential to maximise the buildings air test score.



Tighteners ensure good levels of air tightness.

Where sufficient design co-ordination has taken place ahead of the CLT frame contractors manufacturing deadline, service holes can be factory drilled (below). This is particularly beneficial for SVP and Service Risers which are larger than most service holes and would be very labour intensive to drill on site.

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Doorways arrive partially cut to ensure CLT panel stability during transportation and lifting. These must then be cut out on site. The example below shows a partially cut door frame; the timber had to be removed to permit the screed and under floor heating to pass through the doorway.

Fixing plates positioned across doorway supports should clearly be avoided.

Door partially cut to ensure CLT panel stability during transportation/lifting.

The use of steel beams may be necessary to achieve very large spans. However, glulam is preferable to steel as it permits minor differential movement in the timber.

To achieve the same strength as a steel beam, a glulam beam is typically much larger; there is hence a trade off between glulam which permits differential movement but takes up a large amount of ceiling void space and steel which is less flexible but maintains a good sized ceiling plenum.

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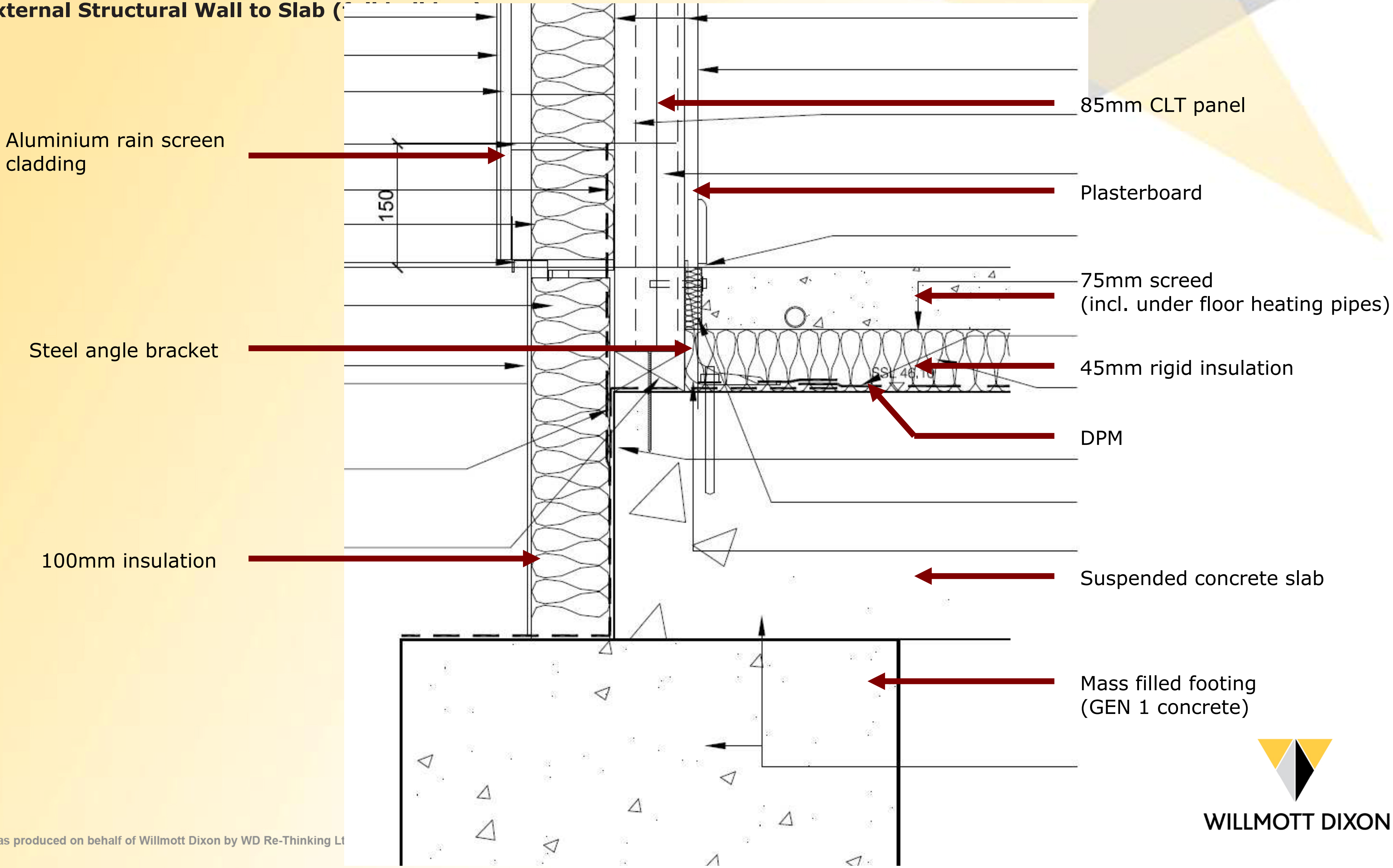
Standard Design Details
Non-Residential Buildings

External Structural Wall to Slab (



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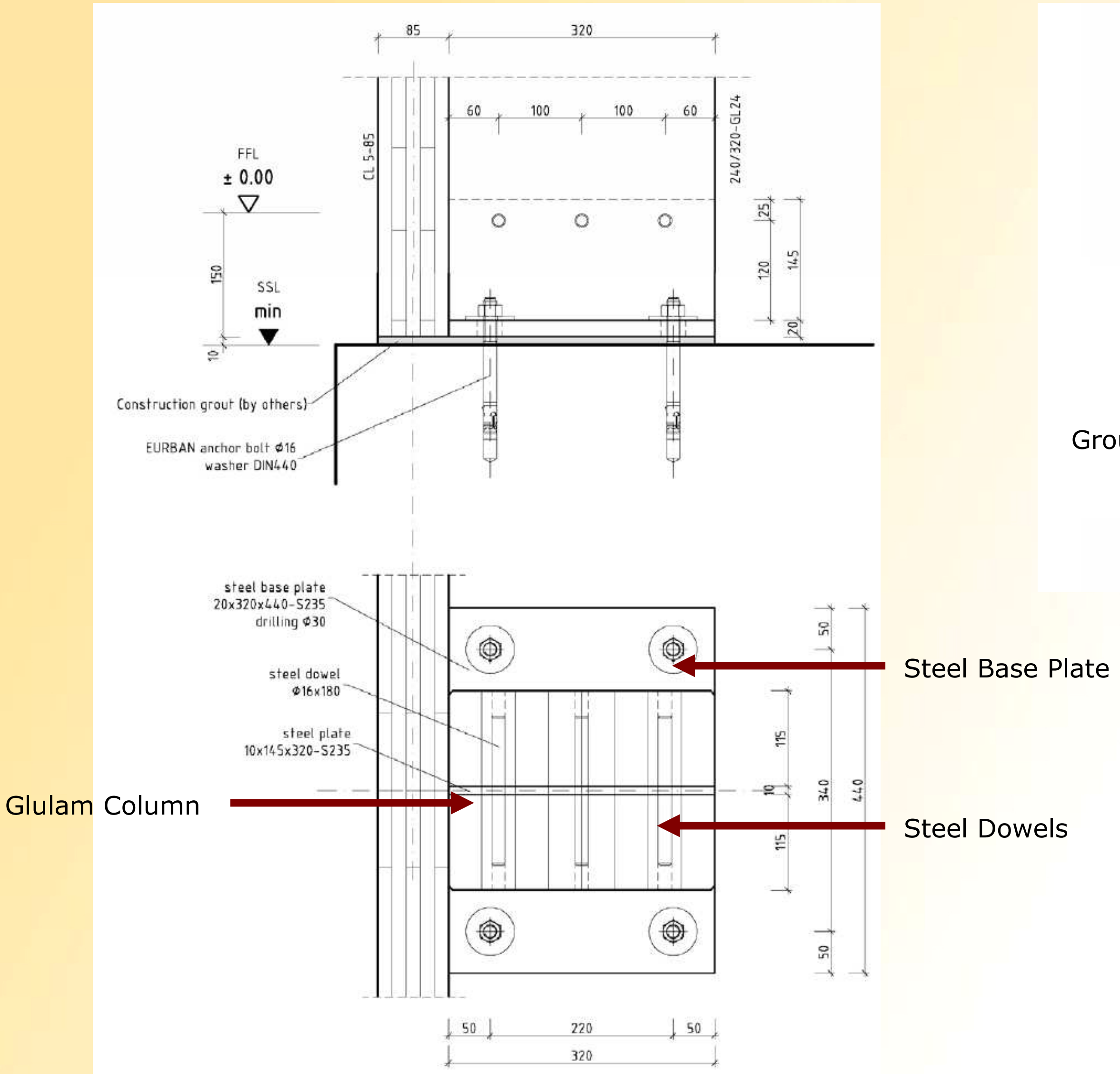
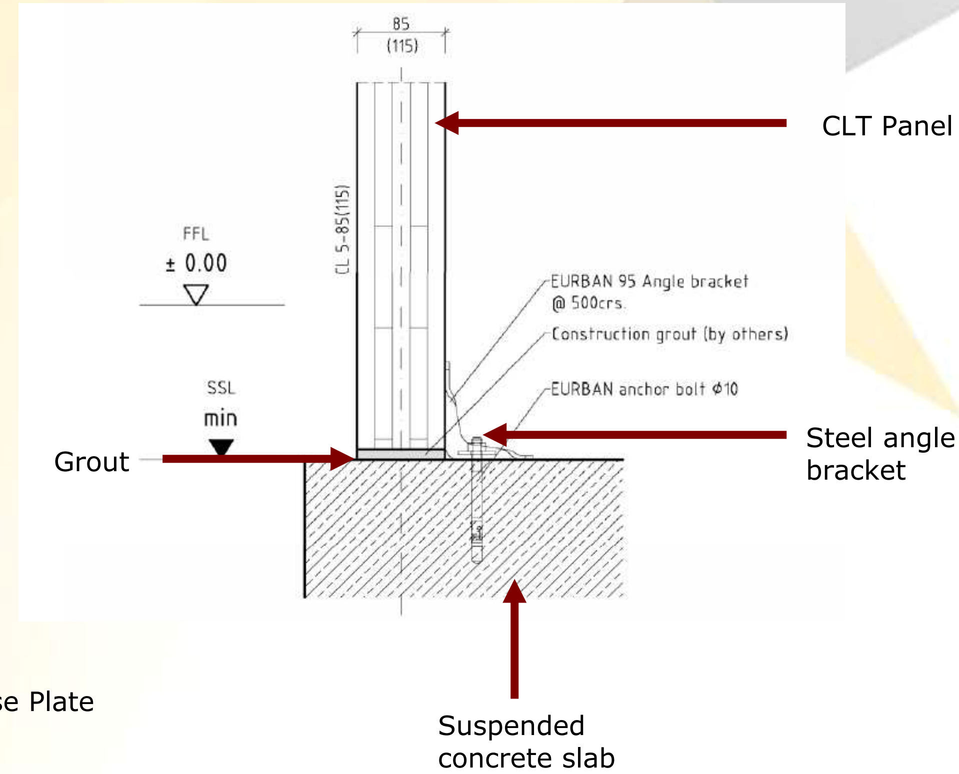
Glulam Column to Steel Base Plate



Non-Structural Internal Wall to Slab



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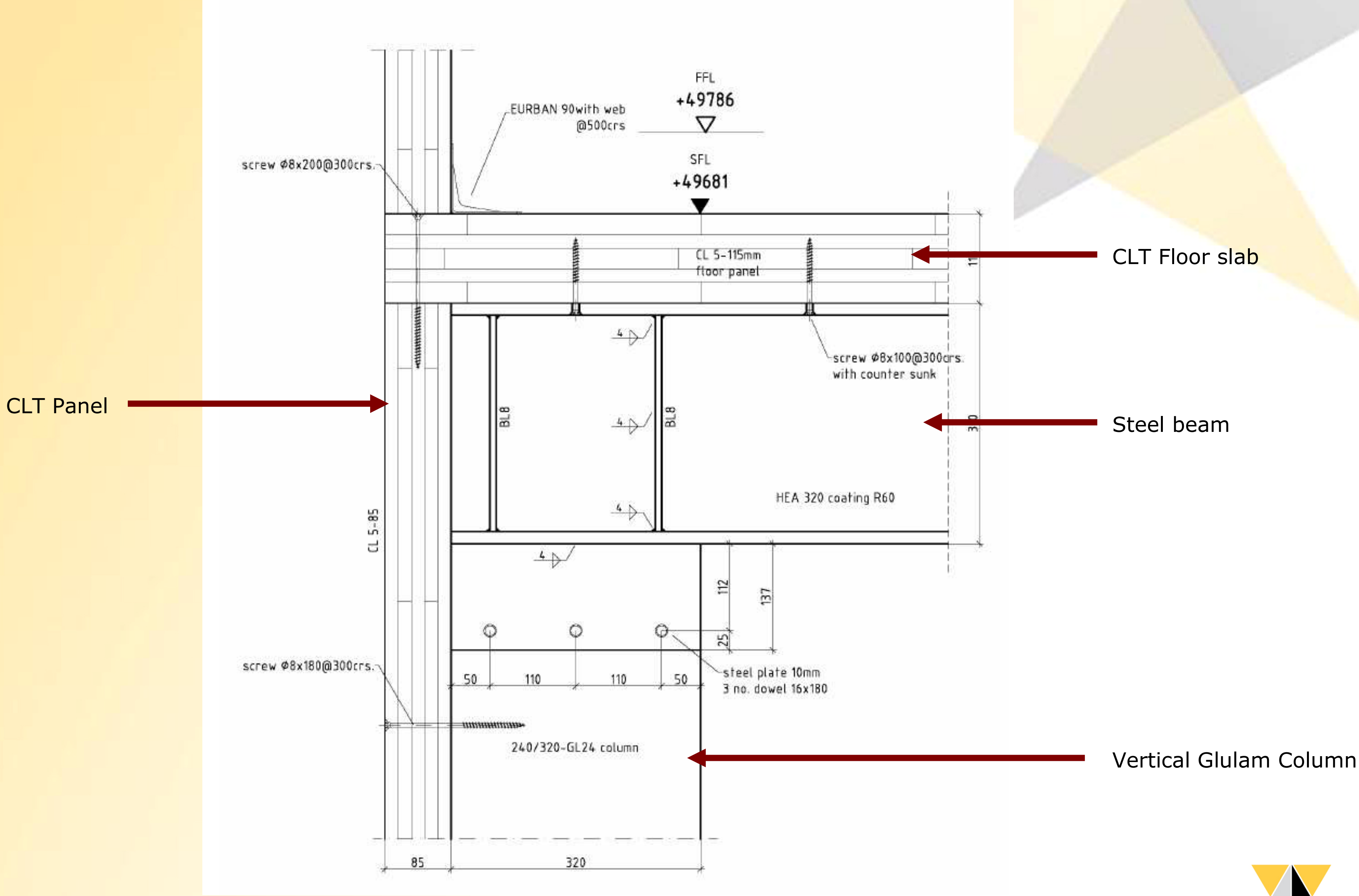
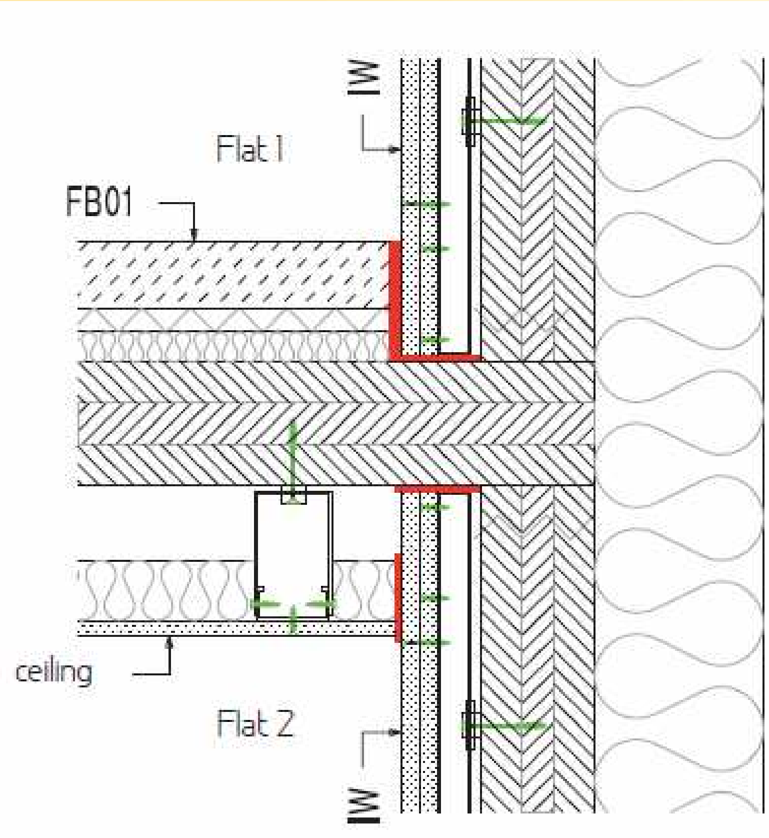
CLT Floor Slab to External Structural CLT Wall

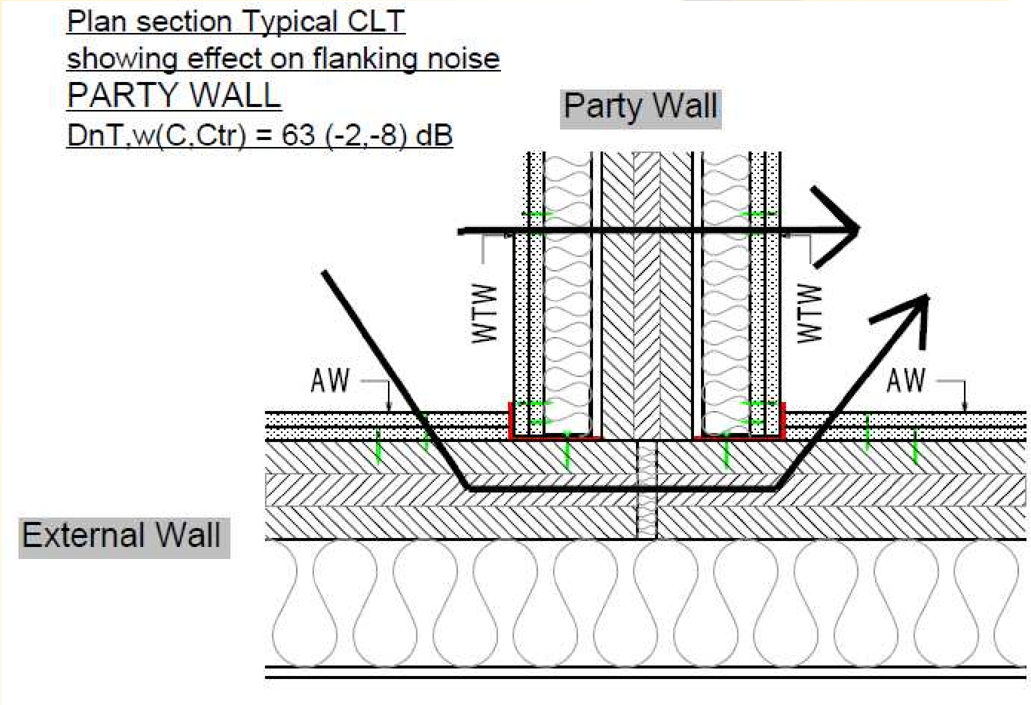


Standard Design Details
Residential Buildings

External Wall/Floor Junction Detail



Internal Party Wall Detail



2 Layers of 15mm wall board to each side of the Party Walls with independent metal frames with 50mm Isover acoustic mineral wool in each side.

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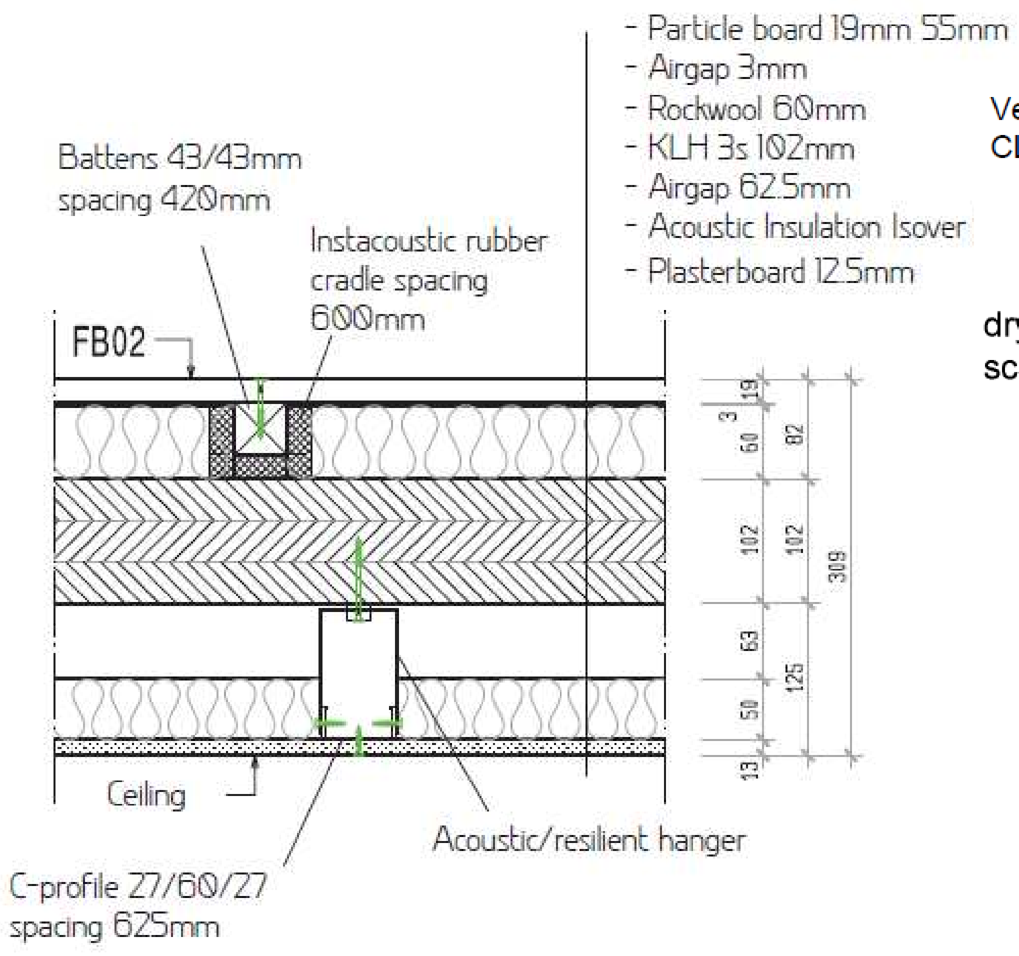
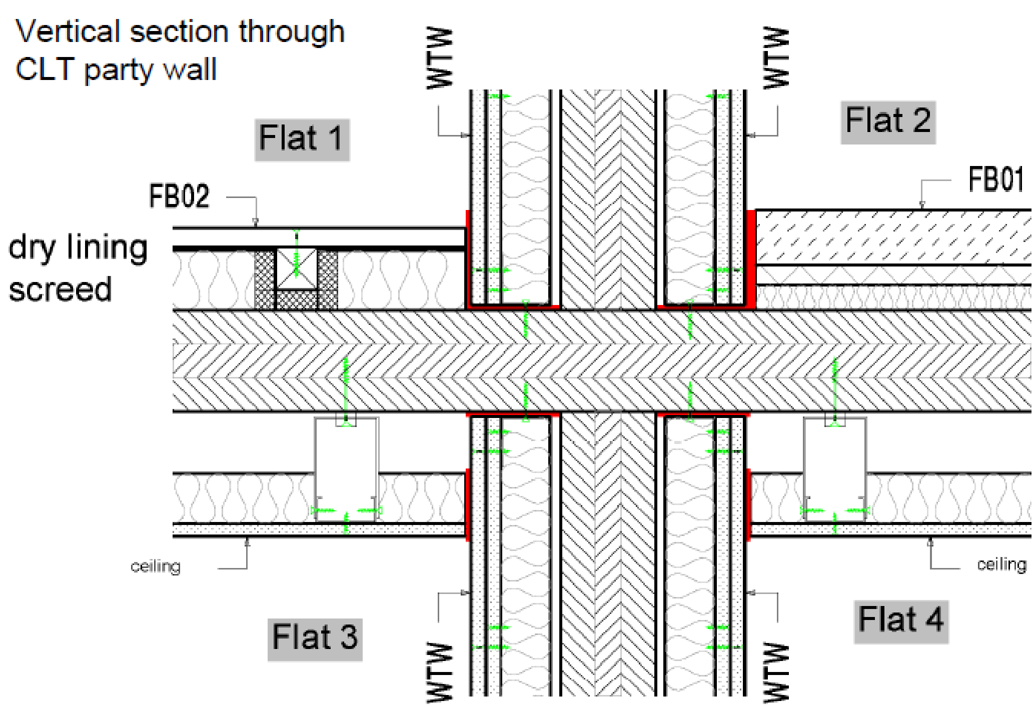
Party Floor Detail



Party Wall Detail (Vertical Section)



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Health and Safety

<u>Note</u>: The information contained in this section is for guidance only. No works should commence on site without an approved site specific Method Statement and Risk Assessment.

CLT panels are normally delivered to site on articulated lorries marked 'special load'.

Where possible, lorries should be offloaded within the Willmott Dixon site compound and the offloading process must be supervised by either a Site Safety Supervisor from the Sub-Contractor or a member of the Willmott Dixon Site Team. The arrival of the lorry should be supervised by a qualified Banksmen.

On sites where space is restricted and offloading inside the site compound is not possible, the offloading process must be supervised by both a Site Safety Supervisor from the Sub-Contractor and a member of the Willmott Dixon Team. In addition to this, a Lift Supervisor must be present.

An operative harnessed to a pre-installed lifting strop whilst the crane lifts and positions the previous panel.

Under no circumstances must the lorry driver leave his/her vehicle without the necessary PPE required for that site.

Under no circumstances must the lorry driver become involved in the offloading of the CLT panels. Drivers should remain in their cabs or in the site accommodation (where panels are being lifted over the cab).

No persons should climb on top of the lorry without being harnessed to the crane inertia reel or one of the pre-installed lifting strops. Where operatives harness to the lifting strops, they should wear a full body harness with a 1.5m fixed lanyard.

An operative harnessed to the crane inertia reel whilst preparing for the next lift.

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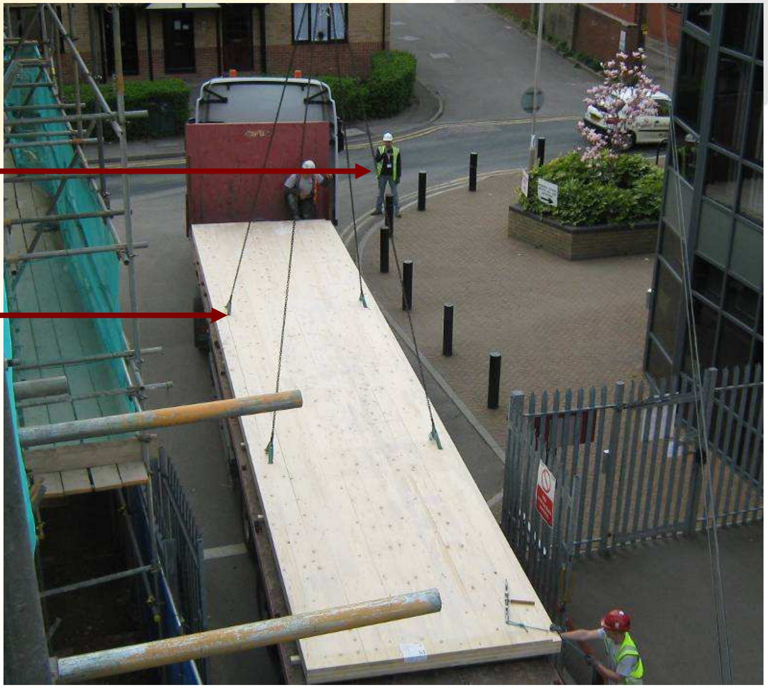
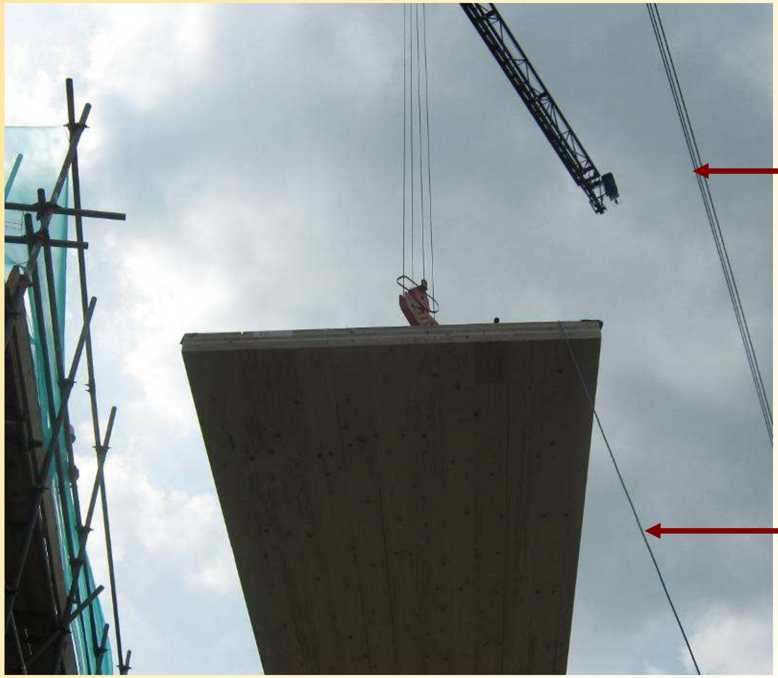


A member of the WD site team supervising a lift outside the site compound.

Panel lifted using the pre-installed certified lifting strops.

In line with WD policy, all lifts should be noted on the 'schedule of lifts' and appended to the permit to lift. Copies should be kept with both the crane driver and the WD Site Team.



Overhead power cables.

Panels should not be lifted in medium to high winds.

Panel lifted with a guide rope to prevent movement in light winds.

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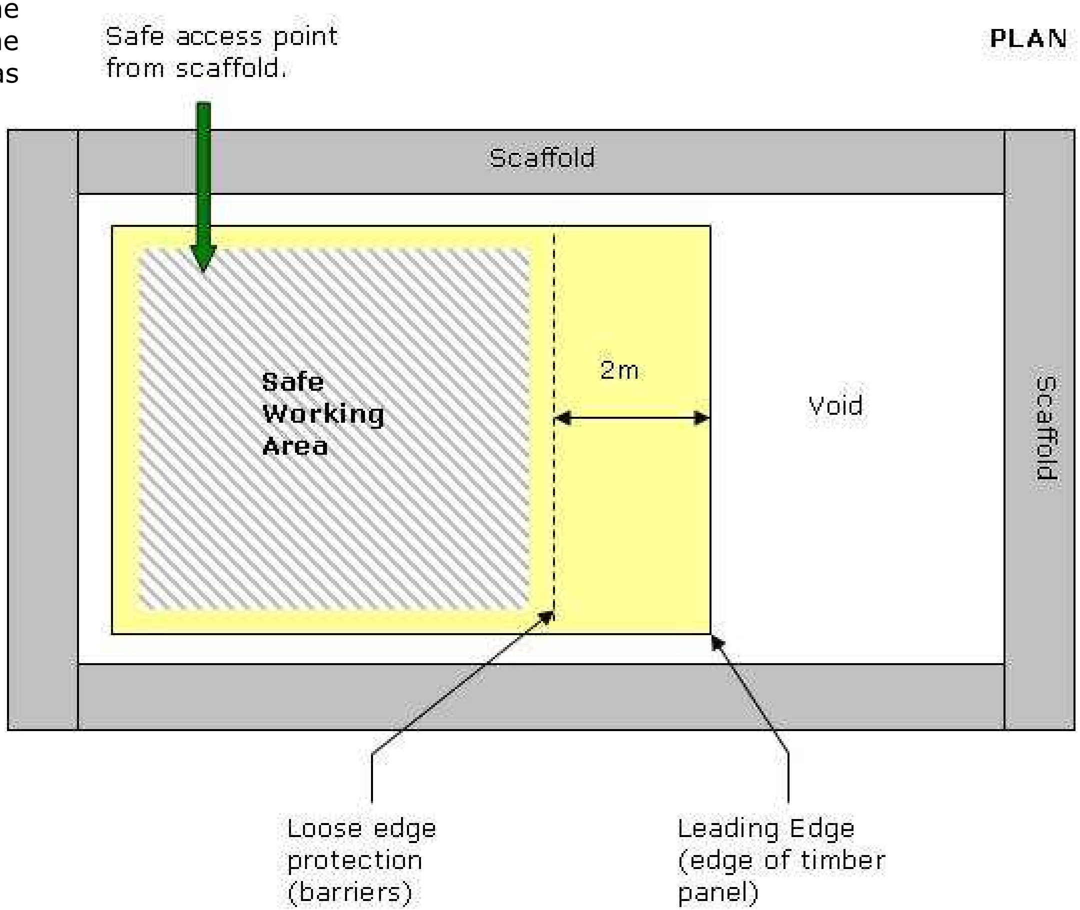
Where panels have been laid and fixed and a safe working area has been created, loose safety barriers should be positioned no less than 2m from the leading edge. Where fixed safety barriers are used these should be no less than 1 m from the leading edge.

On sites where space is restricted, scaffold barriers across the leading edge may be considered. The speed of the timber frame erection should be considered when choosing this option as scaffold may be to be continually altered.

Fixed safety barriers positioned 1m from the leading edge.



Where a safe working area has yet to be created (for example for panels have just been laid and require fixing), operatives should be harnessed to the crane inertia reel.

Unsafe working area (panels laid but not fixed).

Operative harnessed to crane inertia reel.

Nets may be used as an additional fall arrest measure.

The use of nets does **not** negate the need for harnesses and edge protection as mentioned above.

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Contractors

Eurban

Eurban are a UK based company, providing engineered cross laminated timber structures that are manufactured off site ready for assembly in a quick, clean and precise manner.

Structures are designed by Eurban's in house engineers to EuroCode 5 using 3D modelling and engineering software. By being both engineer and contractor, Eurban sell themselves on offering a service that permits design decisions with a high degree of cost certainty.

Eurban believe that the fundamental difference between their service and a product manufacturer lies in the motivation behind material sales. They see themselves very much independently of product manufacturers and enjoy the flexibility of being able to source materials from any supplier.

All timber provided by Eurban is either FSC or PEFC certified making it an ideal material choice with regards to sustainability, embodied carbon and BREEAM ratings. The system sits well with Willmott Dixon Capital Works' market position of being an environmentally responsible and considerate contracting company, leading through innovation rather than simply being a passenger to legislation.

The use of Eurban on Willmott Dixon Construction projects to date has impressed clients and proven a valuable learning resource for their organisations (schools). Projects completed include St Agnes Primary in Manchester (£5.2m) (2008) and Kendrick School in Reading (£2.6m) (2009). Waingels College in Reading (£27.3m) and Bewbush Healthy Living Centre in Crawley (£5.0m) are currently being constructed on site (March 2010).

Whilst the delivery of both St. Agnes Primary and Kendrick School can be deemed successful, a number of issues surrounded the design and construction of each scheme respectively and the sharing of knowledge, information and experiences between the Willmott Dixon Construction project teams did not occur.

A key concern to Willmott Dixon is the use of various systems across different projects and a lack of design standardisation or familiarity amongst project design teams. When asked about this, Eurban explained that the identification of the right product for a project has as a number of variable components; timber exposure and finish, the process of design, drawing, co-ordination, fabrication and eventual delivery. The reasoning behind the product selection for each project is outlined in the case studies that follow.The key issues surrounding each project are examined and the common ground between them identified.

Eurban Directors and members of the Willmott Dixon Pre-Construction and Construction teams in both LCO Manchester and LCO Cobham were consulted in the production of this case study.

EURBAN

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KLH

KLH UK Ltd was formed in 2005 as a London based subsidiary of KLH Massivholz (based in Austria), specialising in the supply and erection of cross-laminated structural timber frame systems.

KLH believe they have developed sustainable, cost effective and practical structural timber solutions. Their timber is sourced direct from a responsibly managed forest before being processed and engineered in KLH's own dedicated factory and delivered to site ready for assembly. This presents clients (such as Willmott Dixon) with a shallow supply chain and offers accountability for products right back to their point of extraction. Dealing with one entity may also be more straightforward from a commercial perspective; European exchange rates cannot be dictated by a separate manufacturer and the overheads and profit margins of only one company will be applied to the product/service cost.

KLH specialise in education projects and have delivered a number of schemes across the Greater London area to date including Kingsdale School (a pathfinder project to the Southwark BSF programme). This is particularly interesting to Willmott Dixon, given that over 60% of group turnover is secured from education with the potential for further work through BSF programmes where LCO's seek to become Private Sector Partners (PSP).

KLH acknowledge the importance of sustainable construction and appear to have strong sustainability principles embedded into their corporate vision and approach. All timber used is PEFC certified and the production process employed works to a zero-waste system. Regular audits are carried out to calculate the CO_2 emissions generated by delivery vehicles and this is offset against the carbon stored within the buildings superstructure.

In addition to this, KLH recognise that acoustic and fire protection issues are inherent in the delivery of structural timber frames and have a dedicated supply chain of acoustic and fire engineering consultants whom they work with.

KLH UK has received much positive press recently (*Contract Journal*, *Architect's Journal* and *Construction News*). The apparent 'flagship' project is Lauriston Primary School in Hackney (Galliford Try) which featured in an article in *Construction Manager* (March 2009).

KLH UK is an attractive supplier to Willmott Dixon, particularly given their firm understanding of sustainability, their education sector specialism and their seemingly robust corporate structure. These three factors alone set the company aside from other UK competitors, although questions remain over the range of products available and whether or not the souring of timber from a larger manufacturer (such as FinnForest) might offer greater flexibility in obtaining the correct product solution for a project.

KLH UK

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Case Studies

St. Agnes Primary School

<u>Client</u>: Manchester City Council
<u>Timber Frame Contractor</u>: Eurban Ltd.
<u>Exact System Used</u>: Crosslam and Glulam (Switzerland)

<u>Construction Period</u>: 10/12/07 – 20/4/09
<u>Contract No</u>: A00001
<u>Contract Value</u>: £5,192,500

<u>Business Unit</u>: LCO Manchester
<u>Project Team</u>: Andre Witter (Construction Manager), Iain Geldard (Design Manager), Andrew Smith (Building Manager), Darren Palmer (Commercial Manager), Michael Iwaniszak (QS).

St Agnes Primary School was constructed between December 2007 and April 2009. The project involved the decanting of the existing operational school into temporary accommodation for a 12 month period whilst the construction of a new 3 storey Primary School took place on the site of the original building.

The building was constructed using a combination of Crosslam and Glulam which was manufactured in Switzerland. The main reasons for this (cited by Eurban) were;

- Weather protection: the material had fully edge glued external and internal lamellas.
- Surface Finish: much of the structure was to be left exposed so needed to be edge glued.
- The Crosslam and Glulam materials could be procured from the same sawmill: being a large order, it was economical to source a single supplier for both components.
- Financial: this suited Eurban's payment term arrangements with Willmott Dixon and their cash flow requirements.

The site team were impressed with the innovation and ingenuity behind the system. A building was erected in a matter of weeks and, despite some issues with weatherproofing on site, this eased the construction of the superstructure considerably.

One key problem was holes for the first and second fix M&E installations. This created a headache for the on-site team where *every* service hole had to be pre-approved by Eurban's engineers.

Eurban's order value was placed for £825,000 (15.8% of the contract value).

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Kendrick School

Client: Reading Borough Council
Timber Frame Contractor: Eurban Ltd.
Exact System Used: Lenotech (supplied by Finnforest, Germany)

Construction Period: 10/1/09 – 7/9/09
Contract No: E390
Contract Value: £2,635,000

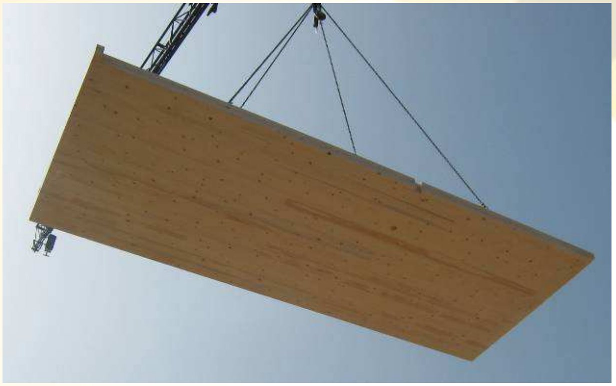
Business Unit: LCO Cobham
Project Team: Lee Bushell (Construction Manager), Mathewe Bennett (Design Manager), Leon Bastajian (Senior Building Manager), Fraser Keep (Commercial Manager), Nick Wilner (QS).

The Kendrick School project involved the construction of a new 3 storey Sixth Form Block on the site of an existing single storey prefabricated Modern Languages block which was initially demolished. The superstructure took just 4 ½ weeks to erect and was extremely swift and straightforward to install on site.

A number of minor issues were raised, notably by the tight physical constraints of the site and the careful management of delivery unloading that this demanded. Material was often double handled and took 6-7 hours to unload. Eurban completed their works half a week behind programme.

However, it should be noted that this was deemed the best solution given the nature of the site constraints. More traditional forms of construction would have encountered similar difficulties with more significant cost and programme implications.

Despite the major service holes and risers being co-ordinated and pre-cut, additional holes for the first and second fix M&E installations needed to be drilled. This created a scenario similar to where every service hole had to be approved by Eurban's engineers.



The building was constructed using the Lenotech system manufactured in Germany. The main reasons for this (cited by Eurban) were;

- Kendrick School was a smaller project (panels could be manufactured in Germany whilst the small volume of Glulam could come from a separate supplier).
- Very few surfaces were left exposed (so did not require an edge glued lamination).
- Installation was being undertaken during dryer months of the year.
- The scale of the works package order was within the manufacturers credit insurance requirement.

The works package value for Eurban was circa £260,000 (9.9% of the contract value).

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Waingels College

Client: Wokingham Borough Council
Timber Frame Contractor: Eurban Ltd.
Exact System Used: Crosslam and Glulam (Switzerland)

Construction Period: 6/4/09 – 31/10/11
Contract No: E393
Contract Value: £27,342,700

Business Unit: LCO Cobham
Project Team: Neil Fox (Construction Manager), Ayo Allu (Design Manager), Ian Edwards (Senior Building Manager), Chris Wardle (Commercial), Faye Allen (QS).

Works to Waingels College involve the demolition of the majority of the existing school followed by the construction of new teaching and administration blocks. The remaining areas of the school are to be refurbished. The new development takes the form of 4 separate 2-storey blocks constructed using CLT.

A key issue arising from the Pre-Construction period was the exchange rate between the Euro and Sterling. The European currency strengthening against Sterling over the duration of the Pre-Construction period (August 2008 to March 2009) raised the prospect of elevated costs from Eurban, an issue that was eventually overcome through fixing rates with the supplier, FinnForest.

Acoustic issues experienced on both St Agnes Primary and Kendrick School were overcome by the use of insulated panel ‘cassettes’ similar to a SIPS panel system. These arrived on site pre-insulated with acoustic relief on the underside to act as ceiling attenuation.

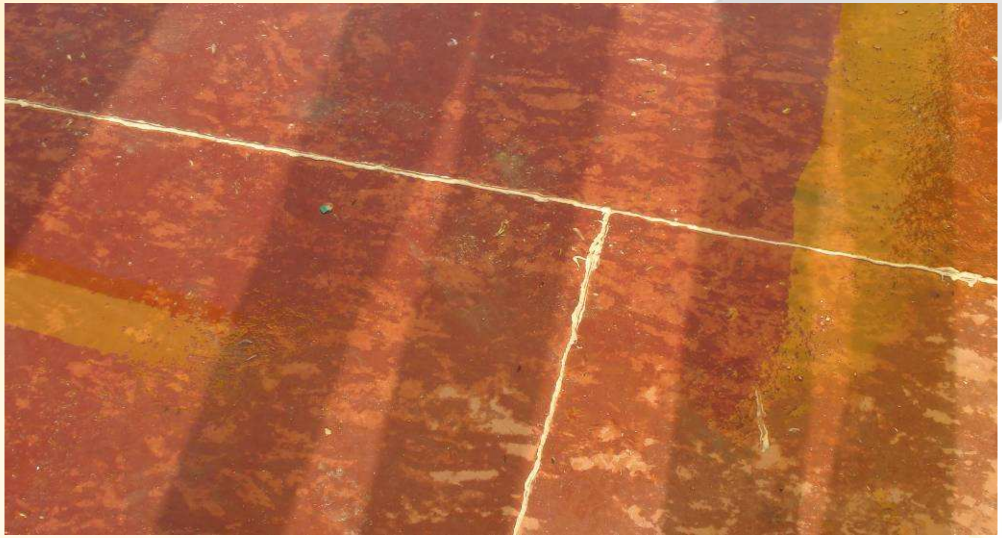
The building was constructed using a combination of Crosslam and Glulam which was manufactured in Switzerland. The main reasons for this (cited by Eurban) were;

- Weather protection: the material requires fully edge glued external and internal lamellas.
- The fabrication expertise for acoustic floor and roof cassettes (technical approvals and test data for various system components).
- Surface Finish: much of the structure is to be left exposed so needs to be edge glued.
- The Crosslam and Glulam materials will be procured from the same sawmill: being a large order, it is economically viable to source a single supplier for both components.
- Financial: Larger credit limits with fixed material prices and exchange rates over an extended time period.
- The Overall factory capacity for material manufacture and secondary processing.

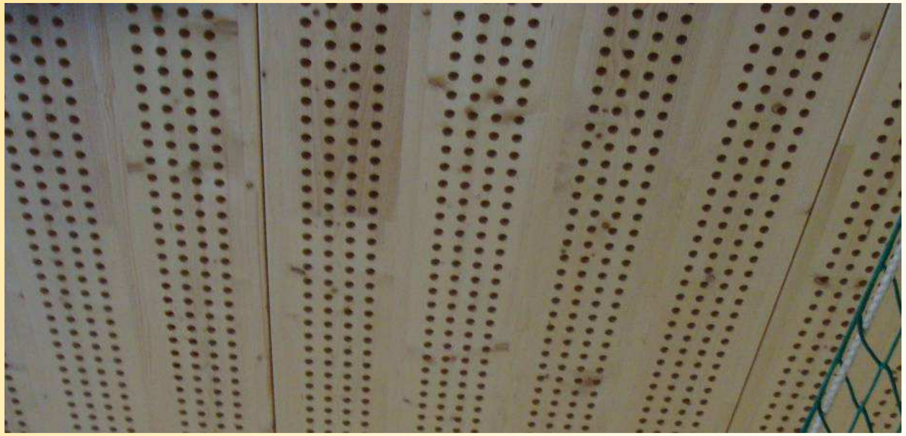
Unlike Kendrick School, the majority of the timber panels used in the construction of Waingels College will be left exposed in the completed building. This means that two thirds of the panels arriving on site have a finished face that needs to be protected during the remaining construction period. Panels were delivered to site lined in a thin fabric sheet which protects it from both sunlight bleaching and impact damage from other trades.

Eurban’s works package value was circa £4,000,000 (14% of the total contract value).

A thin fabric sheet is used to protect CLT panels from sunlight bleaching and other trades on site.



A temporary water proof ply board was laid on top of each floor slab to prevent water penetrating through and staining the exposed CLT panels below. This was removed before the floor screed was laid.



Acoustic relief to the underside of the floor cassette panels (forming the ceilings) provided acoustic attenuation.

Briefing note produced by Fred Mills, Construction Cobham.

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