

# Engineered timber structures in the UK

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## 1. Introduction

This paper examines the types of engineered timber structure being built in the UK and presents examples.

The UK is one of the world's largest net importers of timber and timber products<sup>1</sup>. Whilst wood-based panels, including oriented strand board (OSB), wood chipboard and cement bonded particleboard and medium density fibreboard (MDF) and other fibreboard are all manufactured in UK, laminated timber products are largely imported. In some ways this is an advantage; there are many manufacturers of wood products and there are competing suppliers for projects. On the other hand, the UK market is reliant on suppliers from outside the country providing sales and support services and products carry the burden of high transport costs.

We often overlook the more modest forms of structure used in domestic buildings, in favour of the more dramatic uses on landmark projects. This paper attempts to cover the whole range. It divides building types into those that incorporate engineered products into systems, those that use engineered systems and those that use customised products. The designers and builders working in these three areas are quite distinct. The first type relies on high levels of repetition; the second on moderate levels and the third is for a customised, one-off structure.

## 2. Engineering Building as Products

### 2.1. Platform Timber Frame

Timber Frame 2000 (TF2000) was one of the most significant timber research projects undertaken in recent years. A collaborative project between the UK Government, TRADA Technology, TRADA, the Building Research Establishment (BRE) and the timber industry, it involved the construction of a six storey, timber frame building – the tallest of its type in the world at the time. Illustration 1 shows the test building under construction.



Illustration 1: TF2000. Image copyright TRADA

This research helped to establish multi-storey timber frame construction in the UK. The work was published as design guidance, addressing, structural stability and robustness, fire safety, differential movement as well as construction process and procedures<sup>2</sup>.

Having completed this major project, the market was opened to the use of timber frame and, in terms of volume, the platform timber frame is now the most established part of the timber industry in UK. It is used extensively in private and social housing, student accommodation, hotels, medical facilities and care homes. Multi-storey construction, of six floors, is common.

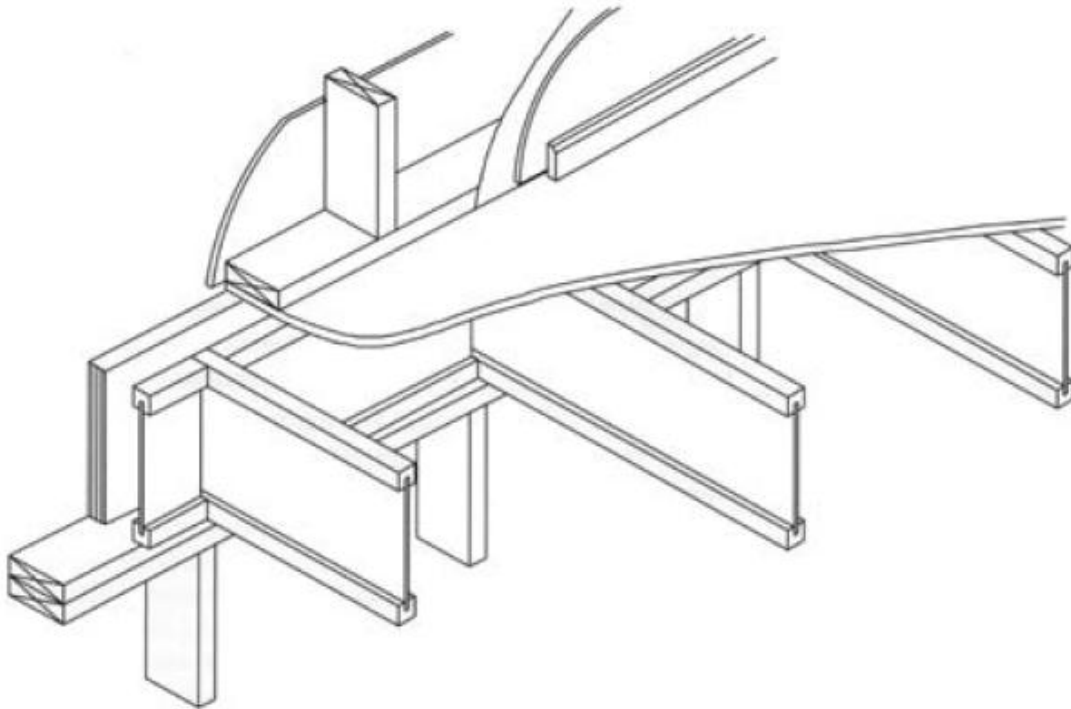


Illustration 2: Platform timber frame incorporating engineered wood products.

Image copyright TRADA This form of construction is highly engineered into a product, which is based on many years of research. As shown in Illustration 2, various engineered wood products are incorporated. These include I-joists for walls and floors, Glued Laminated beams for rim-beams as well as a multitude of panels and membranes. The investment in developing this building type has been large and, having established approvals and warranties, the buildings are made using a set of standard details. The raw materials are low cost, commodity products and the added value in making them into a building is large.

## 2.2. Modcell

For several years, the BRE Centre for Innovative Construction Materials at The University of Bath has been researching the use of prefabricated straw bale panels into a building system. This resulted in the construction of a test building, The BaleHaus, which has been subjected to extensive structural and environmental tests. Out of this research, ModCell<sup>®</sup> is one of the first products to make large-scale, carbon-negative building a commercial reality.

The ModCell<sup>®</sup> system uses straw bale construction to form prefabricated panels, made in a local Flying Factory<sup>™</sup>. Using renewable, locally sourced, carbon sequestering materials, it produces super-insulated, high-performance, low energy 'passive' buildings. The system has been used on a number of buildings and Illustration 3 shows an example.



Illustration 3: Prefabricated straw bale panel system  
Inspire Bradford Business Park. Image copyright ModCell®

As with platform timber frame, this system requires an enormous amount of research development to create the building product. There is plenty of opportunity for design flair, as long as the building does not compromise the details that come together to make the product.



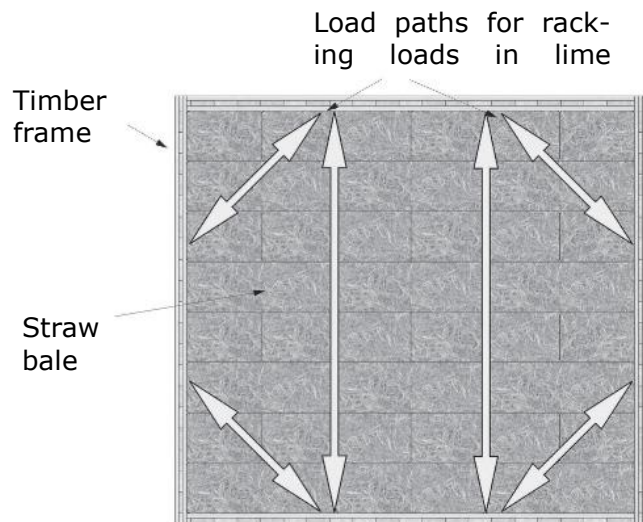
Illustration 4: Prefabrication for BaleHaus® test building and completed building. Photo U of Bath

The BaleHaus® (Illustration 4), was the research bed for this construction form. The panel consists of a laminated timber frame, infilled with straw bales and rendered with a proprietary formulated lime render (Illustration 5)<sup>3,4</sup>.

The timber frame is formed either from, three-ply, cross-laminated timber or from glued laminated timber. The prefabricated straw-bale panels can be formed in a variety of sizes, but most conveniently accommodate the modular size of the standard-size straw bale (nominally 1 m 6 x 0.45 m x 0.35 m) to minimise bale cutting.

Prefabrication of the panels enables the panels to be made to a consistent, reliable quality and construction time is reduced.

Illustration 5: BaleHaus® panel components (patent pending)



A recently awarded €1.6million research project is paving the way for the certification of straw bale buildings, setting recognised industry standards for this technology, pioneered at the University of Bath.

### 3. Engineering Buildings as Systems

#### 3.1. Cross Laminated Timber

Just as the work of TF200 transformed the UK platform timber frame industry and Bale-Haus<sup>®</sup> is set to generate a new form of building, the introduction of cross-laminated timber has released a series of projects that benefit from its special advantages. It is also uses off-site prefabrication; in this case precision engineered panels, using CAD/CAM technology and CNC machinery.

The X-Lam Alliance, a partnership between B&K Structures and Binderholz, has constructed a number of significant buildings and has established a reputation for delivery of high quality buildings to tight budget and programme. They have achieved this by bringing together engineered components, glued laminated timber, cross-laminated timber and roof cassettes.



Illustration 6: Wellington Academy Building. Image copyright X-Lam Alliance

The Wellington Academy Building is a good example. The brief called for “environmental benefits of sustainably sourced timber and the strength and integrity of steel, to be delivered on time and on budget”<sup>5</sup>. Illustration 4 shows the type of construction that can be achieved using this system. It uses cross-laminated panels for the structural walls, floors and roof, combined with exposed glued laminated feature columns. The floors and roofs are made up into cassettes and generate environmental performance of acoustic separation and thermal efficiency. As the connections are typically lapped, screwed and taped, airtightness characteristics of cross laminated timber structures are excellent

School construction provides programme pressures, generated by the need to fit into the timings of a school year. This can be solved by the use of Engineered Building Systems. Manor Longbridge primary school, completed in time for the start of the 2011 autumn term, used over 10,000m<sup>2</sup> of cross laminated timber panels and 100m<sup>3</sup> of Glulam supplied by the X-LAM Alliance. The building surpasses the environmental standard of BREEAM ‘Excellent’. Illustration 5 shows the structure, with panels and openings accurately pre-cut in factory for rapid assembly on site.





Illustration 7: Manor Longbridge primary school under construction.  
Image copyright X-Lam Alliance

## 4. Engineering Buildings as Customised Solutions

### 4.1. Glued-Laminated Timber

Glued-Laminated timber is the main product used in customised engineered timber solutions. It often competes directly with steel, providing solutions for long span. Some of the most exciting buildings recently completed or underway at present in the UK make use of customised glued-laminated timber.

In the UK, there are only small scale manufacturing facilities for glued-laminated timber. For special structures, such as the Scottish Parliament roof, laminated in oak, by Cowley Timberwork<sup>7</sup>, in a factory set up in Lincoln, the industry is capable of creating special facilities. However, at present the UK relies, almost exclusively, on glued laminated imported from outside the country and the case studies shown in this paper all use imported timber. UK expertise comes from the architectural and engineering design community, as well as the constructors. Within a regulatory environment, which has performance as its fundamental basis<sup>8</sup>, the UK is a great place for innovation.

### 4.2. Eton Manor

Eton Manor is a sports and leisure venue, which was the northernmost building of the London 2012 Olympic Park and remains as a permanent venue as part of the 2012 Olympic legacy. PJ Steer Consulting Engineers designed the timber structure for the Timber contractor, Wood Newton.

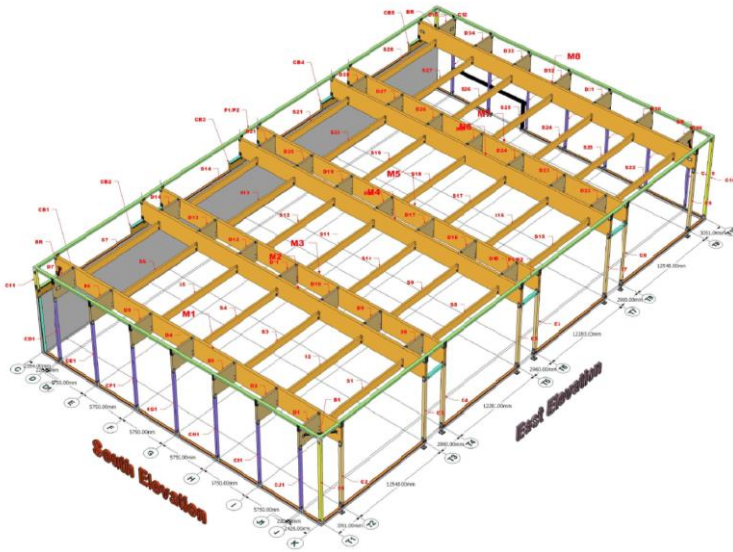


Illustration 7: Eton Manor sports facility. Plan. Image copyright PJ Steer

It is a long span structure, built to a tight programme and budget. Glulam was used for the main beams, which are over 39 metres and are constructed from 330 x 2450 GL24h glulam (Illustration 7). The glulam manufacturer, James, located in Brécey, France, manufactured the beams in four pieces; they were then glued together to make the full-size beam (Illustration 8). Lamination used standard Melamine Urea Formaldehyde (MUF) adhesive. For joining the pieces, a new formulation of gap-filling MUF was used.

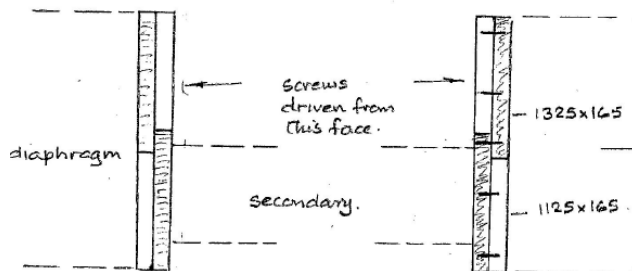


Illustration 7: Eton Manor sports facility. Make up of main beam. Image copyright PJ Steer.



Illustration 7: Eton Manor sports facility. Installation of main beams. Image copyright PJ Steer.





## 6. The Forum. The University of Exeter

Wikinson Eyre were architects for the new Forum building for The University of Exeter. Buro Happold provided all engineering design services, including structure. The roof form is complex, covering a courtyard space between new and existing buildings. The structure consists of a triangular grillage of straight glulam beams, which are pairs of 90 x 450mm deep GL32h glued laminated sections. Illustration 9 shows the structural layout. Connections are made using steel flitch plates of thickness varying from 15mm to 40mm.



Illustration 9: The Forum, the University of Exeter. Structural plan. Image copyright Buro Happold

The roof has a gentle flowing undulating form (Illustration 10). There are high stresses in the beams and some beams have a continuous steel plate. The bolted plate flitch joints are reinforced with vertical screws. The contractor for the roof was SH Structures, with Constructional Timbers fabricating and supplying the timber components.



Illustration 10: The Forum, the University of Exeter. Completed roof Copyright Hufton and Crow



## 7. Crossrail Station, Canary Wharf, London

The largest timber construction in UK is under fabrication at present and will go to site in the summer of 2013. This is a canopy roof for client Canary Wharf Contractors Ltd. The design team is architect Foster and Partners with Arup, engineer and Adamsons Associates as executive Architect. Wiehag provide the whole timber roof design including stability, sizing cross sections, connection design and detail. They will manufacture the structure at their factory in Austria and will install it. The canopy is intended to evoke a vessel moored in a dock to honour the maritime heritage of the Canary Wharf area; timber is the natural material to use for the roof (Illustration 11).



Illustration 11: Canary Wharf Crossrail Station. Image: Foster and Partners. Rendering: Wiehag

This project is enormous, it is by far the largest glued laminated timber in UK to date. It is 30 metres in span and 12 metres in height from park slab to ridge (illustration 12). The structure consists of nearly 1500 Glulam members with a maximum length of 9m, some of which are double curved to achieve the desired form at the cantilever. It has 450 steel nodes to connect the glulam elements and form the geometry.

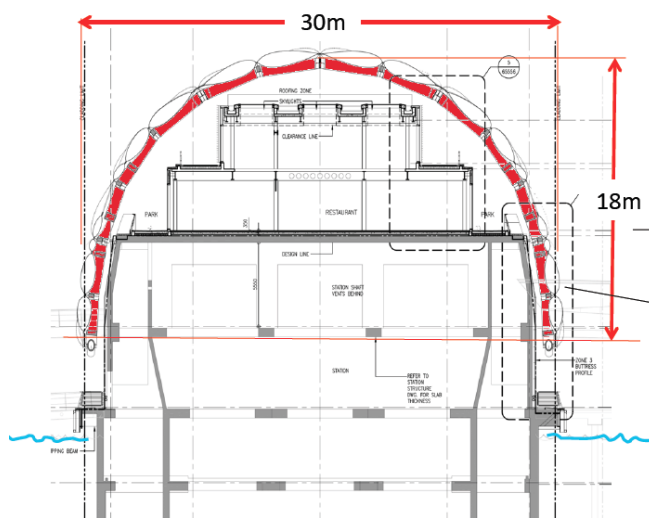


Illustration 12: Canary Wharf Crossrail Station Section. Copyright Wiehag

## 8. Conclusion

The UK construction market is very large and engineered timber construction is still in its infancy. The proportion of timber buildings remains small, as a proportion of the total.

When the TF200 project was promoted, the UK medium rise market (4-8 storeys) was dominated by steel and reinforced concrete construction and this is still the case. At EcoBuild 2013, Steve Cook of Wilmott Dixon reported that 22% of his company's domestic construction and just 5% of non-domestic construction is currently in timber. For TF2000, it was reported that a market gain for timber frame of just 5% would equate to additional structural timber sales of 20,000 m<sup>3</sup> and board sales of 6,000 – 10,000m<sup>3</sup> per year<sup>8</sup>. The same applies now.

Many interrelated factors are now coming together to make timber frame the preferred option for construction clients, designers and contractors. These include environmental issues and government drives on sustainability and efficiency. The TF2000 project was designed to assist in promoting the benefits of timber and in particular timber frame to the whole of the construction industry. Current research initiatives are able to achieve the same outcome, both by directly developing new timber systems but also by providing design expertise to generate customised solutions.

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