GRAPHISOFT CUSTOMER STORY

Combining Technology and Tradition

Traditional timber frames are currently enjoying a resurgence in popularity. With recent decades displaying a trend for modern, manmade materials in the construction of buildings, we are now witnessing a counter movement in design tastes that favours more 'traditional' materials such as wood and natural stone. Traditional, however, does not mean low-tech – in fact, quite the opposite.

A timber frame building is a complex structure and even designs for relatively small-scale projects require the highest levels of accuracy and meticulous attention to detail – mistakes are extremely costly. In a unique approach to the issue, a Gloucestershire company is making use of ArchiCAD's 3D modelling capabilities to pre-empt problems on site and identify misalignments or missing elements during quotation and planning stages.

With such specific requirements, though, the company needed a software product flexible enough to accommodate a bespoke add-on that it knew would be necessary to enable details of its specialised operations to be incorporated into the 3D models created. Using ArchiCAD this was smoothly achieved and the net result has been more efficient project delivery, significant time saving, a dramatic reduction in errors, plus extremely satisfied customers and a considerable improvement to bottom line profits.

A timber frame building is a complex structure, requiring the highest levels of accuracy

The Missing Link

The Oak Frame Carpentry Company employs two full-time designers to undertake the planning and design of a range of projects, in both traditional and contemporary styles – from small-scale conservatories and domestic extensions through to houses, bridges and larger structures, such as barn conversions or public buildings (like Chapelfield Retail Development in Norwich, an arcade structure 8m tall and over 60m long incorporating more than 60 tonnes of oak).

Whilst the firm does not have the professional indemnity required to provide legally endorsed architectural plans, architects undertaking the design work will often bow to the company's in-depth knowledge of this building technique. As a result, a great deal of in-house time and effort has always been put into developing detailed design recommendations for the jointing of every timber frame – a crucial aspect of the finished

Individual components must fit together perfectly in three dimensions

structure, taking into account the location, constraints of the material and angles required.

The main preoccupation with such complex jointing is the avoidance of errors which are costly in terms of time, money and materials. Tim Potts, Director of the Oak Frame Carpentry Company, explains further:
"To produce a timber framed structure, individual pieces of timber have to be jointed at one or both ends so that they fit together into an overall frame – if any of these joints is not entirely accurate, the frame will be impossible to piece together. None of the wood we use is uniform so no line is absolutely straight, requiring precise calculation to ensure a perfect match when the sections (which we prefabricate off-site) arrive on-site.

"Sections are laid together in their entirety as a flat plan before arriving on site to check that nothing is missing, but they can be huge and involve any number of complex joints. It's really critical that, when it comes to fitting these components together in three dimensions, they match perfectly (something which cannot be done until on site as dismantling is not easy and risks damage to joints).

"Before the move to 3D design, we had to rely on human skill and experience, but mistakes did happen, and once a piece of timber has been jointed it's irreplaceable. If there is an error, either the whole timber has to be re-sourced, and accurately replaced into the lay-up (costly in terms of materials and labour) or it has to be patched up, taking up valuable man-hours – and these costs must be absorbed in our profit margins."

With the design and specification being so involved and complex, the pricing for each project – established on an individual joint-by-joint basis for every job – is also highly time consuming. And all this input is undertaken before the company can even guarantee it has been awarded the job.

The Perfect fit

In an effort to minimise time input into quotations and maximise the accuracy of designs produced, Potts researched the merits of CAD systems and decided this was the only way to achieve the company's goals.

Graphisoft's ArchiCAD software was selected for its multi-level functioning (adjustments made in one aspect of the design will be passed through to all files, correcting 3D, 2D, spreadsheets etc) and file sharing capabilities.

For his specialist requirements Potts identified the need for a bespoke add-on to ArchiCAD. This was developed by Bristol based software design company and ArchiCAD distributor, Encina, and has become known as Framewright.

Potts remarks, "It was clear from the start that ArchiCAD was truly designed with architects in mind, it has an intrinsically logical format and works in a way that is sympathetic to the architect's own thought process.

Summary

Timber frame structures require the highest levels of accuracy and meticulous attention to detail. The Oak Frame Carpentry Company benefits from ArchiCAD because it:

- eliminates human error in design and cutting
- reduces the man hours and risks involved in making changes
- offers high levels of visualisation for both clients and the workforce
- defines the materials, cutting requirements and labour for each job
- enables all contractors to share a common model eliminating errors
- reduces costs in the workshop and avoids rework costs on-site
- raises the perceived value of products and the level of professionalism
- significantly increases profits by cost control and realistic pricing

Virtual reality: from ArchiCAD to installation

As an added benefit to speeding up quotation and design stages we could see that it had the potential to raise the perceived value of our process and products and minimise on-site errors. However, being such a specialist niche sector of the market, we needed ArchiCAD to perform a number of very specific tasks that other disciplines may never require before we could achieve this. Fortunately, for us, ArchiCAD's flexibility enabled Framewright to be incorporated easily"

Framewright was developed solely to address the Oak Frame Carpentry Company's needs. Specific features included allowances for calculations on curved timber, custom profiles of any section of the design, and the ability to rotate in 3D space. With some framing components obviously having irregular shapes that cannot be described parametrically, the Framewright system will convert a user-defined shape – drawn using any of the standard ArchiCAD tools for drawing polygons – into a framing object.

Furthermore, every object (stored in a GDL [Geometric Description Language] library containing a parametric description of each generic type of timber object) holds detailed information about the dimensions, hours to create each joint, extra length in the timber to allow for the correct cut for the joint specified, weight, volume etc. This is critical to improving the efficiency of the overall process since it means that, once the jointing designs are completed, scheduling plans, estimates, material requirements and labour allocations are all automatically generated.

Not only does this save considerable time and man hours, but also the model created can be used to actually show customers (and subcontractors) what their finished product will look like. Potts comments: "This is an impressive benefit, and one which often helps to 'seal the deal'. Moreover, the perceived value this adds and the level of professionalism it gives, allows us to charge a premium for our work. It, therefore, supports our profit margins from two aspects – helping us to charge a price that genuinely reflects the value of the work we do and avoiding costs incurred by errors that might otherwise inevitably occur during cutting or, more costly still, on site."

Working with ArchiCAD/Framewright

The timber sections are usually laid out carefully, before being taken to site and erected, to check all the parts are there. Joints within these sections can be checked in the workshop , however, joints between each flat section cannot, but nonetheless must match to the millimetre. The sections can be enormous and, in practice, there is no way of checking them before the structure is put together on site. So, creating an accurate library of joints and requirements within the software has offered a new way of working, a way of virtually building the design and checking the plan is correct.

"The Framewright add-on took some 18 months to evolve, but has more than made back our outlay over the two and a half years we have been using it. It is quite straightforward to operate, though more in-depth projects can make use of more complex features.

"Actually starting to use the software properly did take some time, though," he continues. "Since we not only had to learn to use the technology being provided, but also change our systems (and even mind-sets) to

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>
> **Tim Potts, Director of the Oak Frame Carpentry Company**

accommodate the new approach. It meant adjusting the way we think about our designs, the way we quote and charge for them, and the way we present to clients."

The ArchiCAD software is designed with an intelligent cursor that easily identifies halfway and divide and measure points on the fly., or selects sections for viewing elevations or 3D cut-aways. It also utilises GDL objects: scale sensitive 2D and 3D views that include data attributes that when incorporated into a model also include parametric information (such as weight, joint type, hours required to create the object, excess material needed). These GDL objects are readily reusable as each is able to record many attributes but requires little disk space to store. Therefore developing libraries with tens or hundreds of objects is convenient and economic. Each piece of timber is saved as a GDL object and then used within the design to ensure the required precision is achieved.

Because the software stores standard objects and data rather than defined joint profiles, it provides a very powerful tool which allows the Carpentry Company to experiment with different designs and plan bills of materials and programmes accordingly.

"If I select a standard piece of linear timber from the GDL library and want to add a particular type of joint at either end, the software immediately updates the impact of this decision on the overall design," explains Potts. "The areas affected might include the amount of labour I should allocate to carry out the work, or the quantity of extra materials I will need to order.

"We would not usually see our design in 3D until it is actually put together, this literally gives us another dimension! It is not so much that problems are identified, it is more that they simply do not occur – except in cases where the error is due to elements outside of our calculations, such as an issue with the site."

Spreadsheets, 2D plans, material requirements and scheduling documents are all produced directly from the details included within the ArchiCAD model. This significantly reduces set-up time for each project, ultimately enabling the company to handle a greater number of projects, and, with the added perceived value, allowing a significant premium to be charged.

"Being able to actually show clients what to expect is a further benefit," says Potts. "With 2D plans it is often difficult for a customer to visualise how the finished product will look, using this software we can show all aspects of the design, including how it might fit within its context, and changes can be made quickly and easily. Of course, it also helps the

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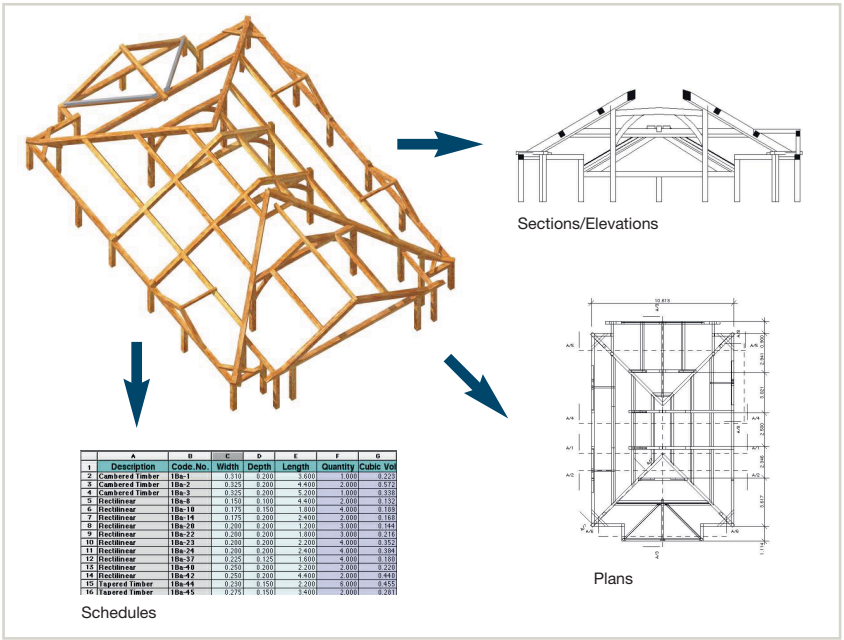


Sections/Elevations

Plans

	A	B	C	D	E	F	G
1	Description	Code.No.	Width	Depth	Length	Quantity	Cubic Vol
2	Cambered Timber	10a-1	0.310	0.200	3.600	1.000	0.223
3	Cambered Timber	10a-2	0.325	0.200	4.400	2.000	0.572
4	Cambered Timber	10a-3	0.325	0.200	5.200	1.000	0.338
5	Rectilinear	10a-8	0.150	0.100	4.400	2.000	0.132
6	Rectilinear	10a-10	0.175	0.150	1.300	4.000	0.109
7	Rectilinear	10a-14	0.175	0.200	2.400	2.000	0.168
8	Rectilinear	10a-20	0.200	0.200	1.200	3.000	0.144
9	Rectilinear	10a-22	0.200	0.200	1.800	3.000	0.216
10	Rectilinear	10a-23	0.200	0.200	2.200	4.000	0.352
11	Rectilinear	10a-24	0.200	0.200	2.400	4.000	0.384
12	Rectilinear	10a-37	0.225	0.125	1.600	4.000	0.180
13	Rectilinear	10a-40	0.250	0.200	2.200	2.000	0.220
14	Rectilinear	10a-42	0.250	0.200	4.400	2.000	0.440
15	Tapered Timber	10a-44	0.230	0.150	3.200	8.000	0.455
16	Tapered Timber	10a-45	0.275	0.150	3.400	2.000	0.281

Schedules

ArchiCAD helps the company to be seen as high-tech, professional and reliable

carpenters to have a 3D illustration to refer to when the joints are being cut and the frame assembled in the workshop. Customers are usually very impressed by this and tend to see the company as high-tech, professional and reliable as a result."

In addition, the file exchange capabilities (of which Graphisoft is a long time pioneer) have changed the way the company can manage a job. Site information can be imported from an existing CAD file – although initial CAD information is generally not to a high enough standard and often has to be worked on before it achieves the accuracy required – the design is then worked up and, finally, exported back to the architect. This avoids the need for repetitive drafting and, again, saves considerable time.

A case in joint

Indeed, the integration of the new software into the working practice has facilitated a broad range of improvements as particular projects have arisen.

For Britannia House – a 16th Century listed building in Gloucestershire – restoration was a complex concern since special consent was required from the Council in order to progress. Using the 3D modelling to visualise plans to the Council (and to produce the cutting list and workshop drawings) ensured that approval was given quickly and the work was completed accurately.

For technically demanding projects the software has come into its own. As part of a project in Lacock, Wiltshire, the company was asked to design a single storey timber frame to go above a masonry ground floor.

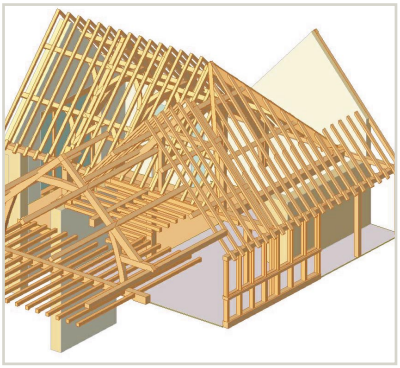
The building was constructed using a series of "Cruck" A-frames (where two halves of a curved tree are used to form an A-shaped structure) with the horizontal members running between them supporting the roof and defining the walls. Clearly the precision of the joint profiles themselves was paramount but it was also necessary to ensure that the timber frame would be compatible (both aesthetically and practically) with the masonry floor and the roof purlins, which would be constructed separately. After an accurate survey of the site masonry, it was discovered that these cruck frames would have to be positioned irregularly, out of parallel with each other and out of square with the walls.

Details from the survey were imported into the software and then the exact positional adjustments of the cruck frames were made in the model, allowing the resulting angles between the horizontal roof purlins in the plane of the roof, and the cruck blades themselves to be calculated. These highly complex and irregular angles were then simply taken from the model and the workshop drawings were produced defining each joint.

"Of course, in the workshop the carpenters had no way of testing whether the odd cuts they were being asked to make would create the desired result," explains Potts. "But when the frame was fully erected onto the masonry on site the purlin line was straight and true, with no further adjustments required. It was certainly a great moment for us to see this project come together with such ease, particularly when one considers the complexities it would have posed without the modelling technology."

"Being able to visualise plans has proved invaluable in many ways, actually," continues Potts. "Not just in terms of technical planning but also to ensure we really do achieve what the client wants. Because making changes using the ArchiCAD software is so straightforward, with adjustments

Adjustments are made automatically at every level when something is changed



made automatically at every level when something is changed, it means we can actually sit with a client and run through 'what if' scenarios."

For example, in a recent project at Waldron Farm, involving a classic add-on conservatory (with open central truss and glazing fitted direct to the oak) the 3D model allowed detailed client consultation over exact proportions, detailing of the oak work, and the overall form of the building. "What we ended up with was an extremely happy customer who will now recommend us – an ideal situation that builds our reputation and allows us to charge more realistically for the work we do."

And the file-sharing capabilities further enhance the efficiency and accuracy of our work. This is particularly well illustrated by a large residential project attached to a historic farm building. The 3D model was initially created from detailed architects' drawings. Using this, the best method of construction for the new frame was identified, with the various disciplines having input. The single information model created in ArchiCAD was then used by all parties involved in the project to store and manage information, rather than each of them creating their own plans separately as is commonly the case. Not only did this avoid considerable redrafting time for each party, since they were effectively able simply to update one-another's drawings, but it also meant that various discrepancies were discovered which could have led to expensive errors on site.

Conclusion

The benefits for the Oak Frame Carpentry Company of using the ArchiCAD 3D modelling software and GDL objects are clear to see. The almost complete elimination of human error and the time savings in terms of man hours could never be matched by manual systems.

Customers also benefit, however, thanks to the high level of visualisation offered by these 3D models. Many clients – particularly on domestic projects – find it difficult to visualise what their finished structure will look like so it's important to be able to give them an impression in a way they can understand.

Tim concludes: "The software enables the entire project to be managed more accurately with no omissions and with no costly re-work. It provides us not only with the price of the frame, but also the cutting list for the sawmill, the workshop time allocation, volumetric data for delivery and, of course, a fully rendered 3D model for visualisation. Almost every aspect of the work flow in this company has been improved."

ArchiCAD and the Framewright add-on are now vital business tools for the Oak Frame Carpentry Company. The initial effort spent integrating the systems into the running of the business has been more than rewarded by the money saved by increased operating efficiencies and the extra margin generated through the delight of satisfied customers .

ArchiCAD comes with a range of special functions to address the needs of similar niche markets, and is also highly flexible in enabling the development of individual solutions to be integrated as add-ons.

GRAPHISOFT®

Graphisoft UK Ltd
Frankland House, Frankland Road, Blagrove, Swindon SN5 8YF. United Kingdom
Tel: +44 (0) 1793 492277 Fax: +44 (0) 1793 492288 www.graphisoft.co.uk info@graphisoft.co.uk