Scottish Borders Woodland Partnership
Project 2: Construction and Sustainable Development using Local Timber

Sub-project 5: Post and Beam

Final Report, November 2009

Gaia Architects
North Woods Construction Ltd.

Aim

Undertaken under the heading of 'Demonstration', this project was devised to explore the potential for an innovative timber jointing method suitable for modern post and beam construction in the Scottish Borders.

Introduction

From their earliest traditions, post and mean structures have relied on having strong, robust joints in order to adequately deflect varying loads down to the ground. Post and beam joints were originally formed from a variety of mortices, tenons, splices and scarfs, invariably with peg fixings (illustration). This was a simple and robust method that enabled relatively skilled workers to construct rigid structures.

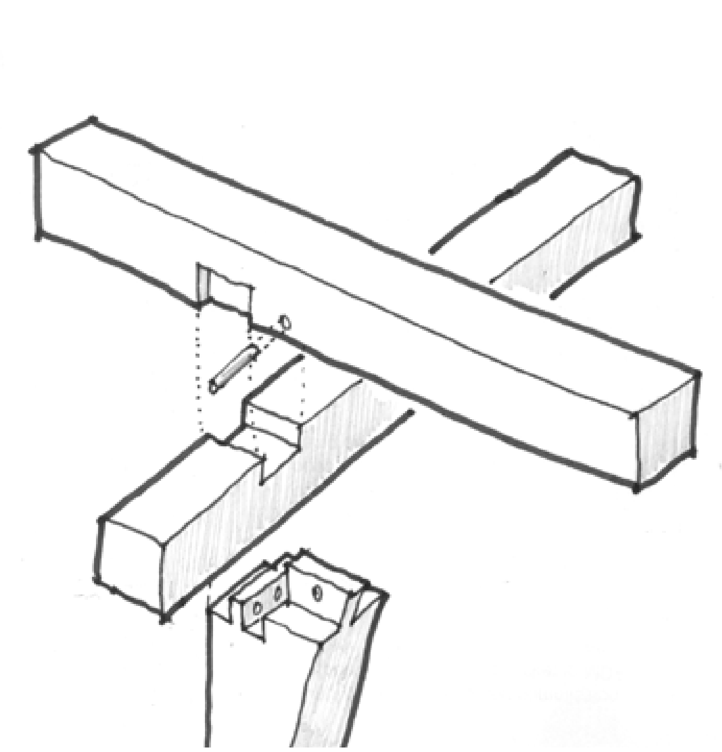

Fig.1. Morticed post and rail joint with jowled post

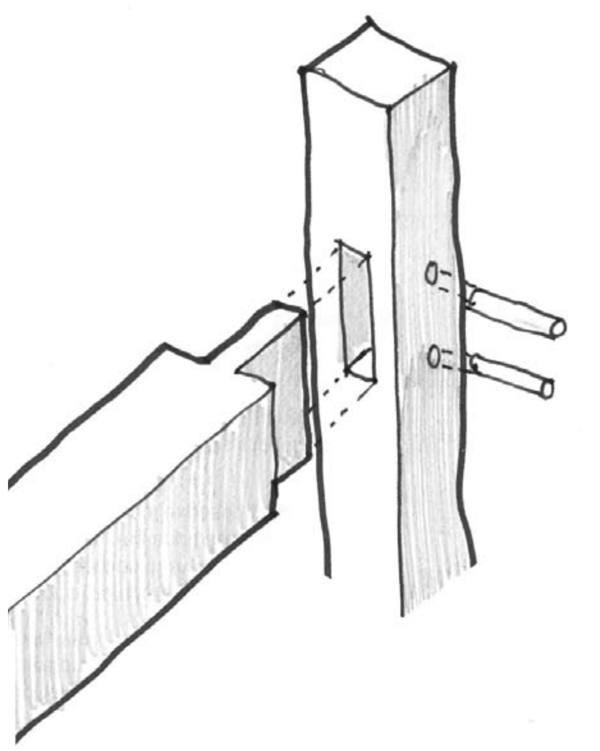

Fig.2. Mortice and tenon joint

As industrialisation took effect in the construction industry, materials became cheaper and relative labour costs increased. This had a direct impact on the use of traditional timber jointing methods, as quicker, cheaper methods were developed. Combined with increasingly ambitious structural design, and the use of steel and concrete posts and beams, traditional pegged timber joints were no longer strong enough or appropriate to connect the structural elements. The result of this was the portal frame joint, where the vertical element (the post) was connected to the horizontal element (the beam) with a secondary, common element.

This secondary element ranges from angle brackets to flitch plates (diagrams), and generally relies on aligning pre-drilled holes to allow fixings to be inserted. Flitch plate connections are now the most common type of post and beam fixing in use, as they allow the structural properties of timber (tension, compression, bending and torsion) to be retained for the majority of the structural elements, while using a different material to take the loads at the connection points.

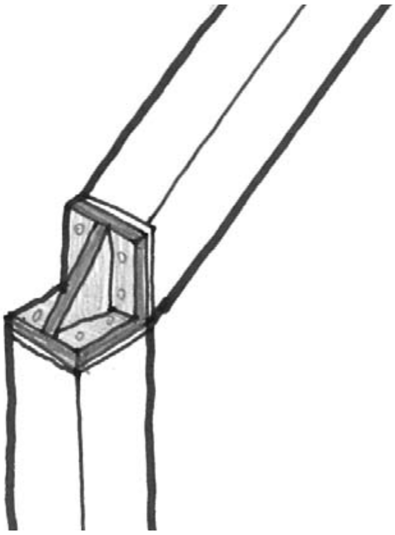

Fig.3. Steel portal frame connector

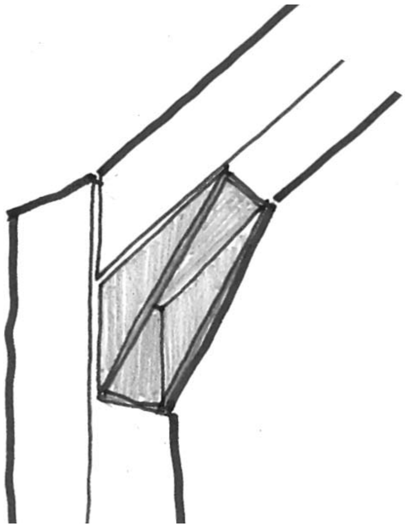

Fig.4. Steel portal frame connector

The importance of alignment can cause problems on some projects, particularly where the tolerances of the materials being used is larger than normal, perhaps due to working on site rather than in a factory. In addition the normal practice of exposing steel connection bolts (illustration) seems to be subject to questions of architectural fashion, and some clients have been known to ask for fixings to be minimised or concealed.

Fig.5. Timber/steel flitch beams with exposed bolts

Fig.6. Timber/steel flitch beams with exposed bolts

To attempt to address these time and aesthetic issues, this demonstration project was used as a vehicle to explore the potential application of drilled, dowel-type fixings for flitch plate connections in post and beam structures.

Fixing System

The fixing system that was researched was the System WS self-drilling dowel, manufactured by

SFS Intec[1] . Fabricated from carbon steel, the dowel is used in constructing multi-layer timber/steel connections and each dowel is capable of passing through up to three 5mm thick steel plates. SFS Intec also market a drill with bespoke stand to help insert the dowels, However, it was found during the project that a standard, hand-held 440v drill, such as those commonly found on building sites, was adequate for this task.
The dowels are inserted through the timber and the steel in a single operation without pre-drilling. With standard connections holes would have to be pre-drilled in both the steel and timber elements.

Fig. 7. Typical factory assembly using dowels

Fig. 8. The dowel

Fig. 9. Portable dowel setting rig

Project organisation

To establish the viability of the jointing method Woodschool[2] were approached, as the project organisers were aware that they had knowledge of local building contractors using homegrown timber for construction projects. In turn, Woodschool recommended approaching Tom Roebuck Concepts (TRC), a local building contractor specialising in post and beam structures.

At the time of the approach in summer 2007 TRC had just been approached by Wooplaw Community Trust to develop design proposals for a bespoke shelter for the recently-purchased community woodland (figures 10 & 11).

The design for the shelter utilised a series of very simple portal frames, with pitched timber rafters

1 http://www.sfsintec.biz/internet/sfsinten.nsf/PageID/System_WS
2 Woodschool, established in 1996 and run by Borders Forest Trust as a sawmill and furniture-making operation, was changed in 2009 to become Real Wood Studios

and vertical timber posts connected with steel flitch plates (figures 10 & 11.).

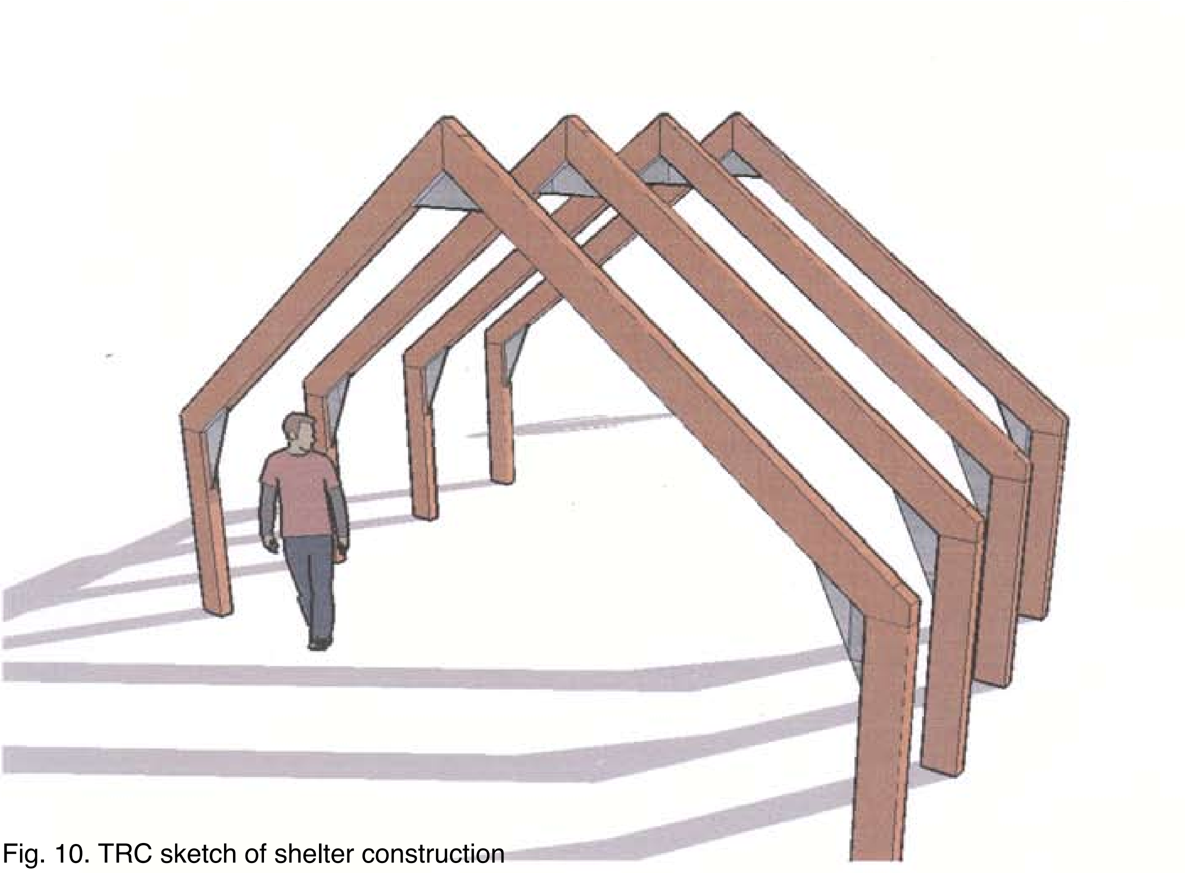

Fig. 10. TRC sketch of shelter construction

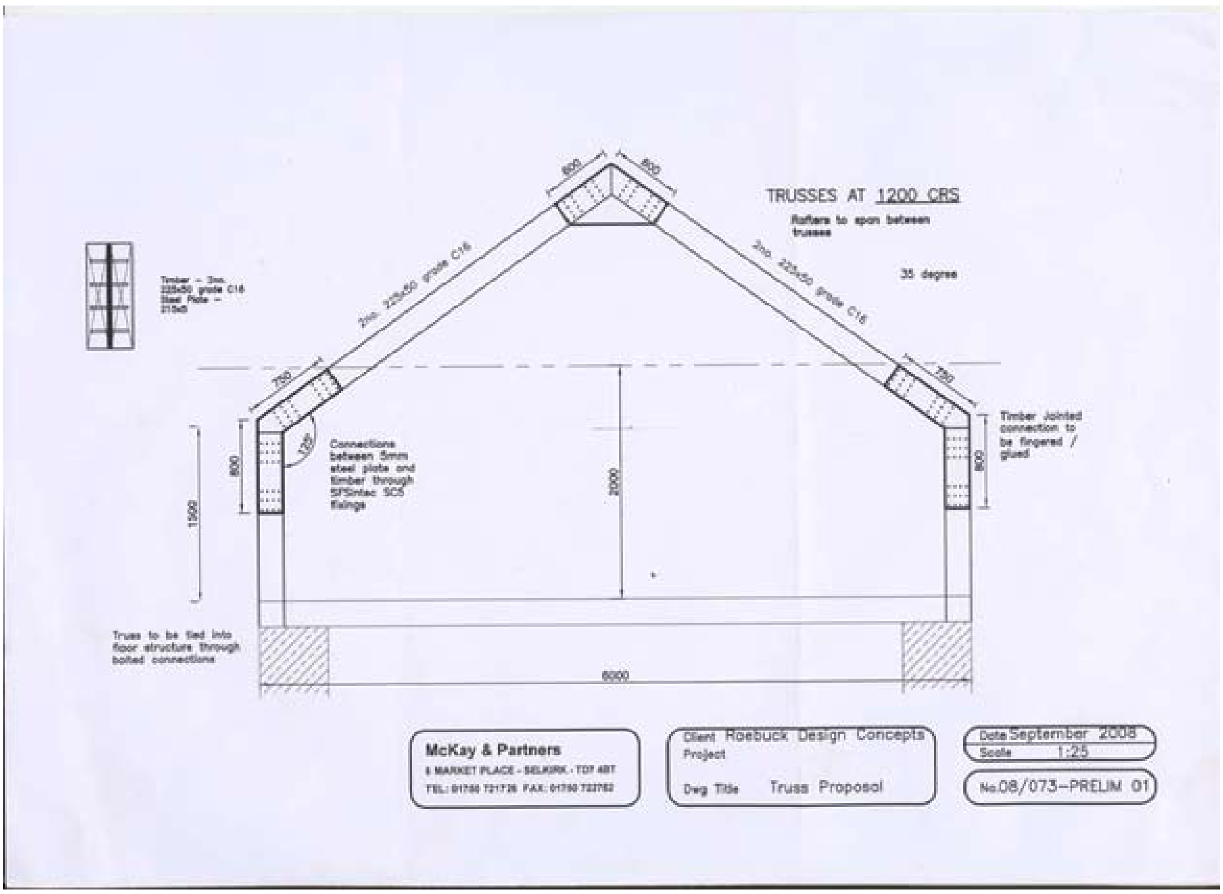

Fig. 11. Structural Engineer's section drawing
for shelter construction

Prior to agreeing to become project partner for the demonstration of the fixing system, the UK distributors of the fixing system visited Woodschool to show how the fixing system was used. The demonstration of the fixing system was carried out by a sales representative from SFS Intec, and was attended by members of Woodchool, TRC and Stuart MacKay of the local structural engineering firm who would be involved in the community shelter design (figures 12-15).

Fig. 12. Using proprietary drill to line up and insert first dowel on test rig

Fig. 13. Dowel inserted by driving down through timber and steel components

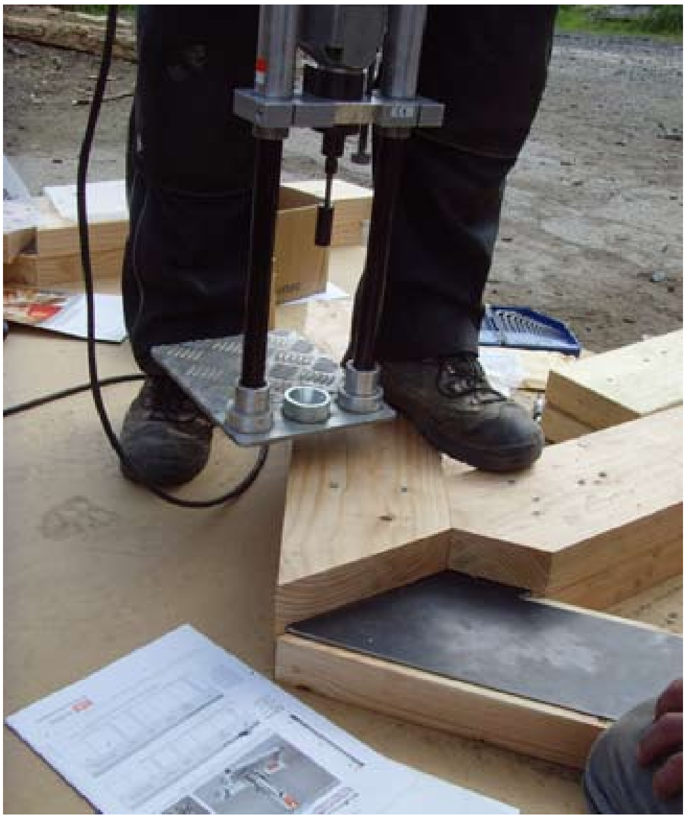

Fig. 14. Inspecting inserted dowel to ensure head is flush with timber surface

Fig. 15. Using hand drill to insert dowels, which achieved same effect.

Following the demonstration TRC confirmed that they were satisfied the proposed fixing system would be suitable for the project at Wooplaw, and noted that the system had a number of potential benefits, including:

- Reduced construction time
- Reduced cost of materials
- Elimination of requirement for pre-drilling, saving time

The next stage of the project included procuring the necessary materials with which to construct the shelter. This included:

Timber - Borders-sourced Douglas fir was milled into posts, rafters and cladding (figures 16 & 17) using Woodschool's sawmilling equipment. This was then stacked, stored and allowed to air dry for a period of 12 months before being used for construction.

Steel - 12mm thick mild steel plates for the post - rafter junctions were formed by a Borders-based blacksmith (figures 18 & 19). TRC had initially experimented with designs for a decorative plywood gusset but structural and cost analysis showed that steel would be a more practical option.

Fig. 16. Douglas fir logs

Fig. 17. Milled timber with structural posts and rafters (left) and clading/sarking boards (right)

Fig. 18. Steel connection plates (left: rafter to post, right: ridge plates)

Fig. 19. Rafter to post steel connector plate

Project outcomes

The resulting shelter for the community group was erected in 12 days by 4 workers. It was found during the construction of the portal frames that the use of the dowels on site posed few problems in terms of achieving good workmanship, and TRC have confirmed that they intend to use the same system on future projects. Figures 20-22 illustrate the site works.

Fig. 20. Dowels being inserted on site with hand drill

Fig. 21. Rafter-post connection detail prior to site application of metal paint

Fig. 22. Shelter constructed. Note construction of rafters with purlins on top, and vertical sarking boards. Also note barely-visible dowel connectors

Conclusions

A number of valuable lessons were learnt during this demonstration project including:

• When using a hand drill to insert the dowels it is extremely important to ensure the torque is at the correct setting to avoid the carbon steel drilling tip of each dowel from shearing off.

• It is relatively difficult to remove the dowels once they are inserted, as this action tends to shear off the carbon steel tip.

• As with other similar fixings (eg screws and nails) if using a hand drill, it is important to ensure that dowels are inserted vertically to avoid twisting or breaking of the dowels.

• If adequate care is taken, a hand drill is as good as the bespoke drill and stand at inserting the dowels.

• Overall the system can provide time and workmanship benefits, and is generally accepted as being a neat and functional timber jointing method for junctions requiring steel connection plates.

Scottish Borders Council support

Scottish Borders Council assisted with the project in the following ways:
• Funding of materials directly related to the demonstration, including timber, fixing bolts and steel flitch plates.
• Funding of time to develop the fixing details

Scottish Borders Council, Gaia Architects and North Woods Construction Ltd would like to thank the project partners for their generous assistance on this project.

Woodschool, Ancrum, Scottish Borders

Tom Roebuck Concepts, Ancrum, Scottish Borders

McKay and Partners, Structural Engineers, Selkirk, Scottish Borders