Development of a New Jointing System for Post and Beam Construction

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Summary

Post and beam construction using green oak timber is becoming popular in the UK for small residential and utilitarian type buildings. Joints in these structures are normally derivatives of the traditional mortise and tenon and can require intensive site work during construction. This paper gives an indication of the structural performance of two alternative joint forms, both designed to allow rapid site erection of these structures, when made with treated softwood members.

1. Introduction

In recent years the UK has seen considerable activity in the use of post and beam construction for both residential and small utilitarian type buildings in which solid green oak timber is used for the principal members. Such is the popularity of these structures that scores of companies have entered the market with their individual designs. In these buildings the joints between members are important since they contribute to the integrity of the structural frames and influence significantly the costs of manufacture and erection. Generally joints are derivatives of the basic mortise and tenon and, due to the fact that many of the companies involved are small, they are often cut via the use of rudimentary machinery. Typical joints are easily able to carry the shear forces caused by gravity loading but even the most highly developed forms, such as those used in Japan where development has gone on for hundreds of years, are unable to offer sufficient resistance moment to enable frames to carry lateral wind loads without the need for bracing. Bracing may take the form of diagonal members, infill panels or sidings formed of competent sheathing material. For stability purposes, it is not necessary to brace all panels and this allows a sense of openness to be expressed in buildings constructed by this method when compared to typical platform frame construction.

As a general rule in the UK, a building is delivered to site in the form of a kit of ready cut parts and, due to the heavy weight of green oak, a crane is required for the lifting and positioning of members. Although mobile cranes are readily available, their hire is an undesirable on cost and, particularly with small structures and small companies, there is a tendency to try and manage without them. Such practice, however, requires the manhandling of heavy timbers which, with ever tightening health and safety regulations, is becoming somewhat problematic. For this reason there is interest in the use of dried and treated softwood timber as an alternative to the green oak, since at the time of construction its density may be as little as half that of the oak, thereby reducing the potential hazards of manhandling.

2. Jointing System Development

In July 2001 the Structural Timber Research Unit (STRU) of the University of Brighton was asked by the company Beamlogic, to carry out a series of structural tests on a jointing system that had been developed for use in post and beam construction utilising dry softwood timber. The system was intended for small single storey multi bay type structures in which the frames could be erected by hand in a matter of hours without the need for skilled labour or a crane. Corner bracing was a feature of the system which, in addition to its aesthetic appeal, was provided so that lateral loads
could be carried by the frame without the need for structural infill or other bracing. A typical arrangement of framing members for the Beamlogic framing system is shown in Figure 1 and an assembled Beamlogic joint is shown in Figure 2.

![Figure 1. The Beamlogic jointing system](image1.png) ![Figure 2. An assembled Beamlogic joint](image2.png)

In addition to the shear and moment loadings mentioned above, joints can be required to resist horizontal tension if beams at roof level are required to resist rafter spread. The company were confident that they could predict the vertical shear capacity of joints using standard procedures but felt that the tensile and the rotational strengths and stiffnesses were better established by testing. Consequently, a number of tests were conducted on joints in tension and on two dimensional frames under racking load. The intention was to modify joint design progressively, in the light of the test results. However, after a considerable amount of testing it was realised that, due to the complexity of the mortise and tenon arrangement involved, it would be necessary to fabricate beams to special order or to a length module since a builder would not be able to modify the length by himself. Such was the commercial disadvantage perceived for this situation that the Beamlogic system was abandoned in favour of a derivative, that was developed under the name Beamlock.

In this system a metal cruciform section takes the place of the mortises in the head of a column and metal insert plates take the place of tenons in the beams. A number of methods of fixing the insert plates into the beams were tried including the use of self drilling steel dowels, which although successful, required location slots of the entire beam depth to be cut in order to accommodate the plates and the necessary number of dowels. The slots proved difficult to cut without the use of heavy machinery and the dowels were also expensive. The method finally adopted was the use of U shaped insert plates that fit into relatively shallow slots that can be cut with a hand held router. This means that beams can be fashioned into the required length by the builder and with minimal difficulty. The insert plates are retained in position by metal cross plates that interlink with them and are themselves located in cross slots that can be similarly cut with ease. Stainless steel is used for all metalwork and is held in place at beam ends by virtue of being a tight fit in its slots or via a dab of foamed adhesive applied before the metalwork is located in its slots. The steel plate that fits over the top of the cruciform section in a column head, and onto a lug on the top of each U shaped beam insert plate, is a critical member in a joint assembly. The system allows a beam to be attached to a column by the insertion of a single steel pin and, in a column face where no beam is fitted, a cast alloy decorative end plates is similarly attached. End plates are key structural components of the jointing system. The diagonal braces finally adopted for this system contain a metal strip that runs centrally through the entire length of the wooden brace. The protruding ends are located in slots cut in the vertical face of the column and the underside face of the beam. They are held in place by a single steel pin that passes through pre-drilled holes in the beam and column members and through the metal strip. The principles of the Beamlock jointing system are shown in Figure 3 and an assembled joint is shown in Figure 4.
2.1 Tension Joint Tests

The principles of the tension tests conducted on each type of joint is shown in Figure 5 and the actual test arrangement with an early Beamlock joint in place is shown in Figure 6.

The tension force was applied at a constant rate of actuator movement of 1.5 mm per minute and the movement of the cross beam with respect to the longitudinal beams was measured with LVDT’s. A range of load – displacement characteristics for both types of joint is shown in Figure 7.
2.2 Frame Racking Tests

Racking tests were conducted on both longitudinal and cross frames made with the two different jointing systems and on a traditional mortise and tenon jointed green oak frame for comparative purposes. The frames were 2.2 m in height and 2.6 m in span and were loaded with the appropriate vertical load. A range of different brace fixings and shoe details was tried to determine their influence on the strength and lateral stiffnesses of the frames. In all cases effective lateral support was provided to the top beam. The test arrangement used for longitudinal frames is shown in Figure 8. Graphs of the sway of the frame at the level of the centreline of the top beam, relative to a point about 120 mm above the mounting bed of the test frame on the column remote from the application of the racking load, are shown for frames made with both types of joint in Figure 9. The graph for the mortise and tenon jointed green oak frame is also shown for comparative purposes.

3. Discussion

There is no comparative evidence available for the tensile strength or stiffness of traditional oak joints but for both types of joint that were tested, the performance seems broadly acceptable. Inspection of the racking test graphs reveals that the performance of frames made with either type of joint is similar to that of the oak frame with the traditional joints.

4. Conclusions

Work continues on development of the Beamlock system with the latest thrust being towards the use of reinforced plastics to replace the stainless steel currently used. The Beamlock jointing system is a structurally sound principle and is already commercially available. The development of this jointing system, and of others that is going on in various parts of the world, reflects the commercial interest in rapid erection systems for post and beam construction.

5. Acknowledgements

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