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Title:	Moment Connections in Timber		

Introduction

Structural connections are categorized as either pinned connections, moment connections or semi-rigid connections. Pinned connections, also referred to as simple connections, are free to rotate under load and are assumed to resist no moment, only shear forces. Moment connections, also referred to as fixed or rigid connections, are restrained against rotation and are capable of resisting both shear forces and moments. Semi-rigid connection lie somewhere in between and are capable of resisting some modest moment.

Common timber joinery connections are almost universally simple pinned connections. Some common scarf joints such as undersquinted stop-splayed scarfs or bladed half-lap scarfs can be considered semi-rigid.

While the technology for developing rigid moment connections in structural steel construction or reinforced concrete construction is well established, the same cannot be said for timber frame construction. Certain characteristics of timber frame construction such as volume change movements of timber, low tensile strength perpendicular to the grain, and low fastener stiffness can make the design of a timber frame moment connection challenging. Failure to give due considerations to these issues can have dire consequences.

Structural Form

The vast majority of timber frame structures built are joined entirely with pinned connections. Lateral loads are commonly resisted by shearwalls or knee braces and the structure is stable with pinned joints.

On rare occasions, situations arise where a timber moment connection cannot be avoided. In other cases, an architect or designer may be unwilling to consider a more efficient structural form using simple pined joinery. Every effort should be made to utilize structural forms for timber frame structures that function with simple joinery. Timber moment connections should be considered a solution of last resort.

Some examples of structural forms where timber moment connections cannot be avoided include:

- Long-span structures or arches where the timber elements cannot be shipped without splicing smaller pieces together. This situation is usually limited to glulam timber structures.
- Curved timber structures that are cut from straight timbers that are joined together. It is advisable to position splices at points of minimum moment so that semi-rigid connections are suitable. Figure 1 illustrates a cruck frame with a scarfed splice that must resist moment for stability of the frame.
- Gable roof structures with no tie beams. If the principal rafters are joined at the ridge with a moment connection, the structure can be engineered to be stable without a tension tie element. This type of moment connection is particularly problematic since the joint is positioned at the point of maximum moment. To avoid needing a moment connection, an alternative solution would be to have a ridge beam, or a pair of principal purlins, support the rafters.

Figure 1 Scarfed cruck splice

When all else fails and timber moment connections are deemed unavoidable, the engineer should proceed with extreme caution.

Volume Change Restraint

Moment connections that utilize steel side plates or kerf plates are problematic. The steel plates tend to restrain volume change movements of the timbers due to changes in moisture content. This is especially troublesome if green timbers are used. This restraint is likely to induce a tension split perpendicular to the grain in the timber.

Figure 2 depicts a moment connection detail that looks good on paper but is not likely to perform well.

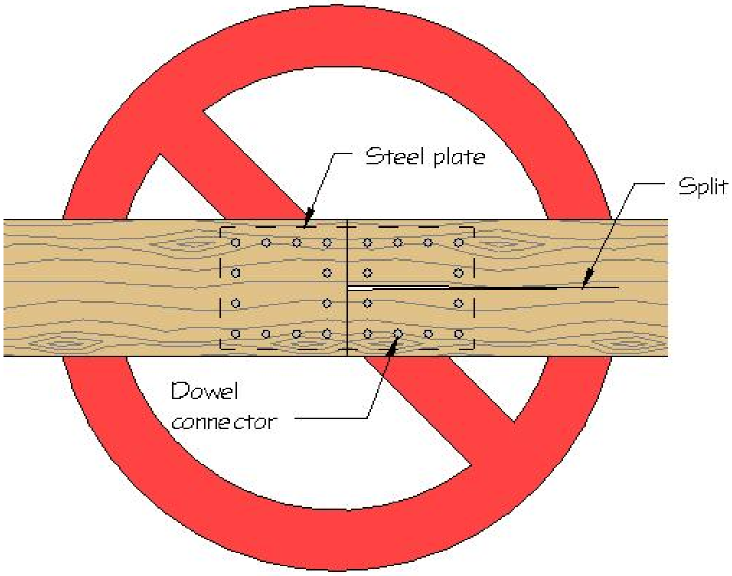

Figure 2 Don't try this!

Moment connection details that have performed well with glulam structures fabricated from kiln dried lumber may not have the same success when used with green timbers. Whenever practical consider using fully seasoned or radio frequency kiln dried timbers.

Tension Perpendicular to the Grain

The tension strength of timber perpendicular to the grain is extremely low in timber. Very small tension stresses across the grain are sufficient to split a timber. The *National Design Specification (NDS)* does not even bother to publish design values for tension perpendicular to the grain.

Figure 3 Failed scarf joint

Splitting caused by restraint of volume change movements has been discussed but splitting can also be caused by a connection that introduces prying forces across the grain.

Figure 3 shows a bladed half-lap scarf that has failed due to tension perpendicular to the grain caused by prying. The scarf was not intended to be a moment connection but attracted moment to itself unintentionally.

Fastener Stiffness

The stiffness of a moment connection is influenced by the fasteners used to transfer forces. A very small amount of fastener deformation can translate into a significant angular rotation of the joint. If a moment connection is intended to perform as a rigid connection rather than semi-rigid then very little fastener deformation can be tolerated.

Bolts holes in timbers and steel gusset plates are typically 1/16” to 1/8” larger than the bolt diameter to allow for ordinary construction tolerances. When a bolt is loaded, it must traverse the slop in the bolt hole before it even engages in bearing. That movement alone can cause a rigid connection to perform as semi-rigid.

Tight-fitting connectors such as self-tapping screws, timber rivets, or shear plates should be considered when rotational stiffness of the joint is important. Figure 4 shows a moment connection detail using shear plate connectors which minimize fastener slip. The detail also does not restrain volume change movements or introduce prying forces into the timbers.

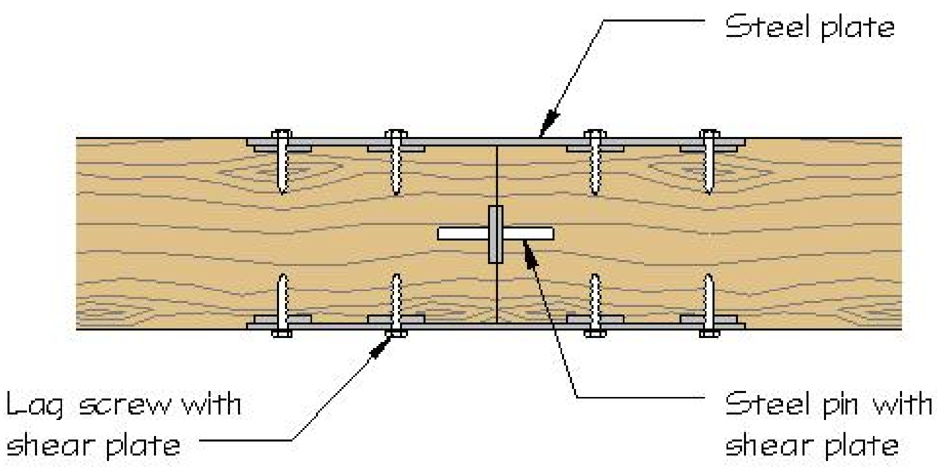

Figure 4 moment connection detail

Conclusion

Moment connections in solid sawn timber present the engineer with challenging issues and demanding constraints. There is little guidance in codes, minimal research literature on the subject, and no generally accepted standardized prescriptive details.

There are recent developments in European products that are promising, but the products have been developed for dry engineered wood applications, are typically expensive, not readily available in North America, and do not have Building Code approval.

Failure to anticipate all potential failure modes of a proposed timber moment connection can result in disappointing performance. Caution is advised!

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