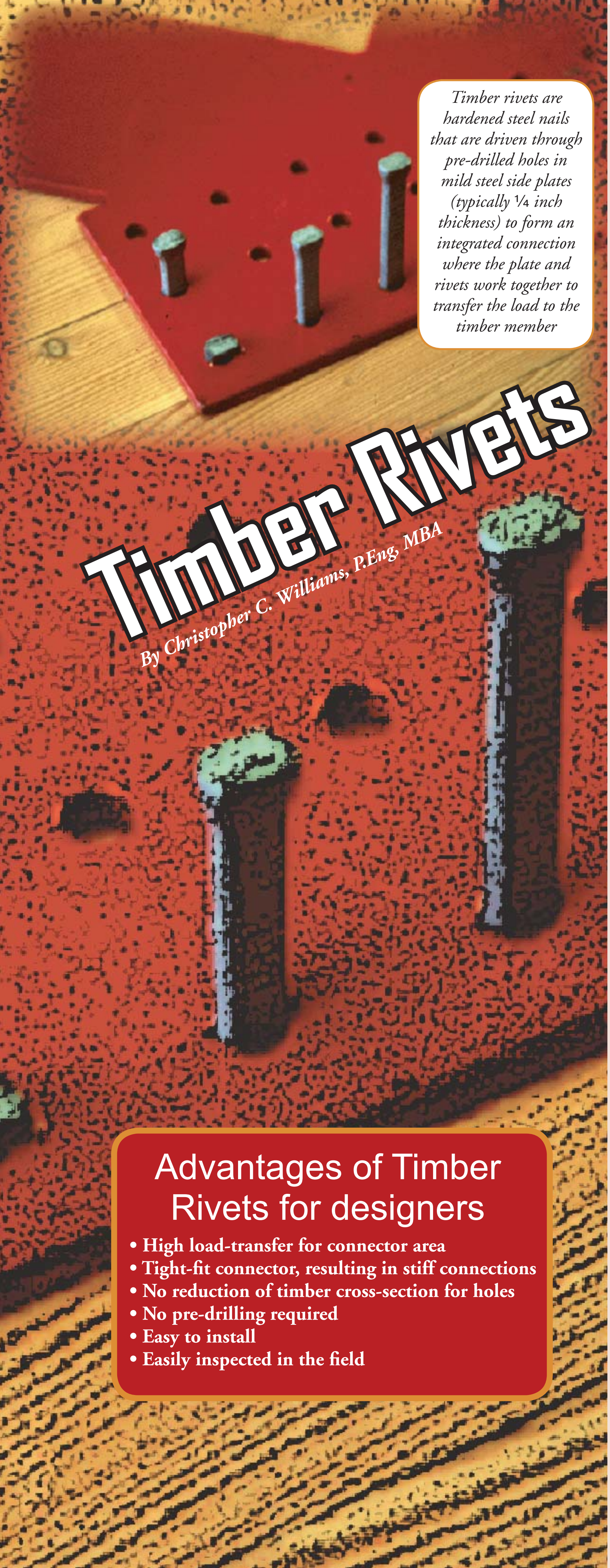


Timber rivets are hardened steel nails that are driven through pre-drilled holes in mild steel side plates (typically ¼ inch thickness) to form an integrated connection where the plate and rivets work together to transfer the load to the timber member

Timber Rivets

By Christopher C. Williams, P.Eng, MBA

Advantages of Timber Rivets for designers

- **High load-transfer for connector area**
- **Tight-fit connector, resulting in stiff connections**
- **No reduction of timber cross-section for holes**
- **No pre-drilling required**
- **Easy to install**
- **Easily inspected in the field**

Over the last decade, timber connection research and field experience has demonstrated some advantages of small diameter tight-fit fasteners over large-diameter fasteners such as bolts. Of this family of fasteners, the one most familiar to North American practitioners is the timber rivet, which has design provisions in the *National Design Specification*® (NDS®) *for Wood Construction* (published by the American Forest & Paper Association). The timber rivet is particularly well suited to the transfer of high loads in heavy timber structures.

About The Timber Rivet

Timber rivets are hardened steel nails that are driven through pre-drilled holes in mild steel side plates (typically ¼-inch thickness) to form an integrated connection, where the plate and rivets work together to transfer the load to the timber member. Rivet groups are normally installed in a rectangular pattern on a 1-inch grid.

The pre-drilled holes in the steel side plates are the same diameter as the wide face of the rivet (¼-inch), making a tight fit between fastener and steel. The rivet has a rounded rectangular cross section (similar to an old-fashioned cut nail) and has a tapered head. Using either a standard hammer or impact hammer, the rivet is driven until the head projects ⅛-inch above the side plate. When seated in this manner, the rivet head slightly deforms the steel side plate and wedges in place, creating a fixity that restricts the rivet head from rotating under load — this contributes to the overall stiffness of the connection. It is worth noting that the timber rivet differs from ordinary nails in that it is not used in wood-to-wood connections — it is the integration of the rivet and steel plate that makes high load transfer possible.

Those familiar with heavy timber design have no doubt been frustrated in the past by massive shear plate groups that cover a significant portion of the timber, and sometimes require the use of larger members just to accommodate the connection. The area required for a rivet connection is usually far less than that for a shear plate or bolted version.

Timber rivets are always driven with the long axis parallel to the grain of the timber, wedging between the fibers, and are installed in a spiral pattern from the outside of the group in towards the center. Because no wood is removed by drilling, the designer is able to make use of the full cross-section of the member. With traditional connectors such as bolts, lag screws, shear plates, and split rings, the member has to be designed using the properties of the net section, resulting in a less efficient use of the member's strength.

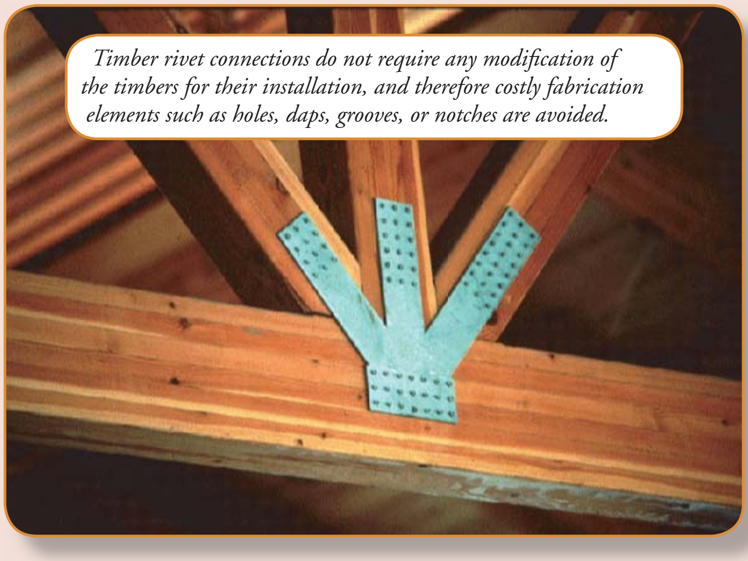
Timber rivets are available in three standard lengths: 1 ½-inch, 2 ½-inches, and 3 ½-inches. The 2 ½-inch length is the most frequently used, since it fits two-sided connections in 5 ⅛-inch wide glued-laminated timber (the most commonly used width). They are easier to use than 3 ½-inch rivets, and their strength is not significantly lower. 3 ½-inch rivets are typically used in larger connections where high force transfer is required, or when it is important to reduce the size of a connection. 1 ½-inch length rivets are most often used in two-sided connections in thinner members (such as 3 ⅛-inch width glulam) to avoid the rivet tips touching each other. On single-sided connections, the penetration depth is limited to 70% of the wood thickness.

It's advisable to use a single rivet length throughout a project, since it reduces the possibility that an installer might mistakenly use the wrong length in a particular connection. This approach isn't always possible, but it's helpful for both the installer and for the peace of mind of the designer.

Design methodology

The timber rivet has been included in the design provisions of the NDS since the 1997 edition, and from that time more and more designers have included timber rivets in their projects. The fact that the design procedures for the timber rivet are included in the United States' most widely recognized timber design code is a significant benefit; many designers are not timber specialists and may have a reluctance to use or approve connectors that lack the backing of a trusted domestic authority.

The design methodology is straightforward, and has the advantage of allowing the designer to predict whether the connection should fail in a ductile manner (through yielding of the rivets) or in a brittle fashion (though failure of the wood). This transparency of predicted failure mode will be of particular interest for designers working in zones with high seismic requirements.



The design equation for the rivet yield mode is simply the strength of a single fastener multiplied by the number of fasteners in the group. However, in larger groups the rivet capacity is often not fully realized, since the timber will yield at a lower load. This concept applies to bolts and other connectors as well, and NDS Appendix E provides a design methodology for checking local stresses in fastener groups. However, E.1.1 specifically states that timber rivet design already accounts for local stress effects. The design of a rivet connection involves the comparison of the rivet-yielding failure mode and the wood failure mode, and designing for the lower of the two capacities.

Wood failure in parallel to grain loading is typically characterized by the mobilization of a wood plug roughly the same size as the connector group. In a perpendicular to grain application, such as a face-mounted beam hanger, the wood will fail by splitting along the grain (tension perpendicular to grain is wood's weakest strength characteristic). The wood strength equations are a function of the group geometry, and the NDS presentation has a number of tables covering a wide range of connection configurations.

Benefits of timber rivet connections

Timber rivet connections have a number of benefits for designers, but the most significant are the high load-transfer capacity and stiffness, and the elimination of costly fabrication associated with other connectors such as bolts and shear plates.

When large load transfers are required in timber connections, the force should be introduced into the member by distributing it as evenly as possible through the cross section. This is much more effective than relying on a smaller area of high stress concentration, as is the case in a bolted connection. Simply put, it's better to have a large number of small diameter fasteners than a small number of large diameter fasteners. This approach makes more efficient use of the timber allowing high loads to be transferred without premature failure of the timber. And, since the stress per connector is lower, it is easier to design the connector to fail in a ductile manner. Another benefit of distributed load transfer is that the effect of a localized growth characteristic such as a knot is less likely to influence the connector group performance.

Those familiar with heavy timber design have no doubt been frustrated in the past by massive shear plate groups that cover a significant portion of the timber, and sometimes require the use of larger members just to accommodate the connection. This can be particularly troublesome in a truss application where a relatively short member can carry a high load, resulting in connection plates so long that they almost touch each other. The area required for a rivet connection is usually far less than that for a shear plate or bolted version. Of course, reducing the connection size also reduces the size of steel side plates, which helps to keep the budget in check.

Since the connectors are tight-fit, they exhibit minimal initial slip under load and as such can develop their design loads without unexpected deformation of the structure. This is particularly important if the designer is using a connection to contribute to the stability of a structure, or if a moment connection is used.

Timber rivet connections do not require any modification of the timbers for their installation, and therefore costly fabrication elements such as holes, daps, grooves, or notches are avoided. This keeps costs down, and in most cases the installation time on-site is not significantly different from that of a more traditional connector. Any designer that has seen an installer struggle to align bolt holes in timber to those in a steel bracket can attest that it is not always a straightforward exercise. There is no special equipment required for installation, and it is easy for site crews to work with them.

Timber rivet connections can usually accommodate adjustment easily, since there are no pre-drilled holes to align between timber and steel. The connections can often simply be moved to the correct position without worrying about losing capacity through slotting holes or reaming. Adjusting a hole to achieve fit-up can compromise the capacity of a connection, and it is difficult to detect a modified hole after a bolted connection is completed: inspecting a rivet installation, however, is a relatively straightforward affair.

Conclusion

Since their introduction into the *NDS*, timber rivets have seen increasing adoption and acceptance from the timber design community. Their high load-transfer characteristics, ease of installation, and flexibility in the field make them a highly effective and reliable connector choice. Small diameter fasteners have shown a significant advance in timber connection technology, and the timber rivet is a readily available and well established example.▪

*Christopher Williams is Vice President of Timber Systems Limited of Toronto, Canada (**www.timsys.com**). Timber Systems Limited provides pre-engineered heavy timber structures to many markets around the world. Christopher can be reached at **cwilliams@timsys.com** for questions.*