

# Heavy Connections

- Bolts
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- Split Rings
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## Bolts

Bolts are used with plates, washers, or more efficiently, in conjunction with split rings or shear plates to connect wood members. They are often used in purlin to beam, beam to column, or column to base connections of wood structures. When bolts are used alone with washers or side plates as shown in Figure 1 below, the load transfer area of the wood is the surface area of the bolt.

Timber connectors such as split rings and shear plates are a means of distributing loads over a larger area of wood and are discussed later in this section.

Several types of bolts as shown in Table 1 below, are used for wood construction with the hexagon head type being the most common. Countersunk heads are used where a flush surface is desired. Carriage bolts can be tightened by turning the nut without holding the bolt since the shoulders under the head grip the wood.

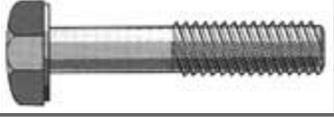
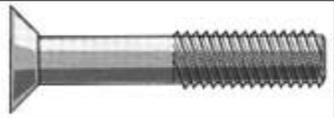
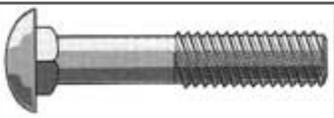
Depending on diameter, bolts are available in lengths from 75mm (3") up to 400mm (16") with other lengths available on special order. Where long length is required, threading rods may be used in lieu of bolts, either alone or with shear connectors.

## Spacing

Placement of bolts is important in design since it can affect load carrying capacity. Minimum end distance is based on bolt diameter and wood species, while minimum edge distance and spacing requirements are based on bolt diameters.

The net section of wood members (area of wood remaining after drilling of holes) in a bolted joint must also be checked by referring to wood engineering standards.

**Table 1: Types of Bolts for Wood Construction**

Bolt Type	Usual Range of diameters		Uses	
	mm	in.		
Finished Hexagon Bolt	6.4 to 38	1/4 to 1-1/2	For countersinking flush or below the surface	
Square Headed Machine Bolt	6.4 to 51	1/4 to 2	Same as finished hexagon bolt but gradually being replaced by them.	
Machine Bolt with Countersunk Head	12.7 to 32	1/2 – 1-1/4	Used where flush surface is required (may have to be used with countersunk washer)	
Carriage Bolt	4.8 to 19	0.19 (No. 10) to 3/4	Used where head may be inaccessible during tightening.	

## Washers

As a minimum, standard cut washers should be used with bolts to keep a bolt head or nut from causing crushing when tightening is taking place. Where a steel plate is used, the head or nut bears directly on steel, and the washers are not required.

Common types of washers are shown in Table 2 below.

If square or round steel plate washers are used, they must be of adequate thickness to prevent cupping and overstressing of the steel. Round plate washers may be used instead of square plate washers for appearance reasons such as for exposed trusses. Beveled washers are necessary where the bolts are not perpendicular to the bearing surface.

Minimum dimensions for washers used in timber connector joints depend on the type of washer and size of the bolt and connector (split rings and shear plates), and are specified in engineering design standards (CAN/CSA-O86.1-M89 and AITC 117-87).

If bolts carry a tensile load, the washers must provide enough bearing area so that resistance in compression perpendicular to the grain of the wood is not exceeded.

## Side Plates

Side plates are frequently used to transfer load from one wood member to another by allowing a butt joint rather than an overlapping joint.

**Table 2: Washers for Bolts and Lag Screws**

<b>Washer Type</b>	<b>Uses</b>	
Standard cut washer	Used for screws and bolts where the loading is lateral. Should not be used with split rings or shear plates.	
Square plate washer	Used for bolts and with split rings and shear plates. Suitable for tensile loads.	
Round plate washer	Used for bolts and with split rings and shear plates. Suitable for tensile loads.	
Ogee (cast iron) washer	Used for bolts and with split rings and shear plates. Suitable for tensile loads.	
Malleable iron washer	Used for bolts and with split rings and shear plates. Suitable for tensile loads.	
Bevel washer	Used where the bolt to member alignment is not perpendicular.	

## Bolt Installation

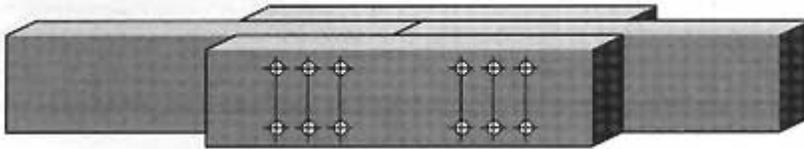
Bolts are installed in holes drilled slightly (1.0 to 2.0mm (1/32" to 1/16")) larger than the bolt diameter to prevent any splitting and stress development that could be caused by installation or subsequent wood shrinkage.

Wood shrinkage requires special consideration in the design of bolted connections for sawn timber because of the potential high moisture content of the members. It is less important in designing connections for glulam, PSL, or other wooden products manufactured at low moisture control.

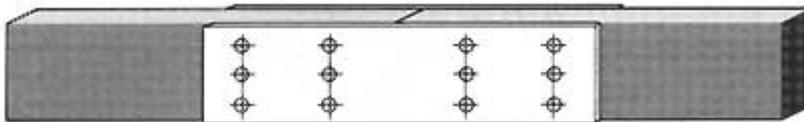
As shrinkage across the grain takes place in timber, movement may be restrained by the steel side plates leading to splitting of the wood. If steel side plates hold bolts further than 125mm (5") apart across the width in a splice joint, separate side plates should be used as in Figure 2 below.

**Figure 2: Types of Bolted Splices**

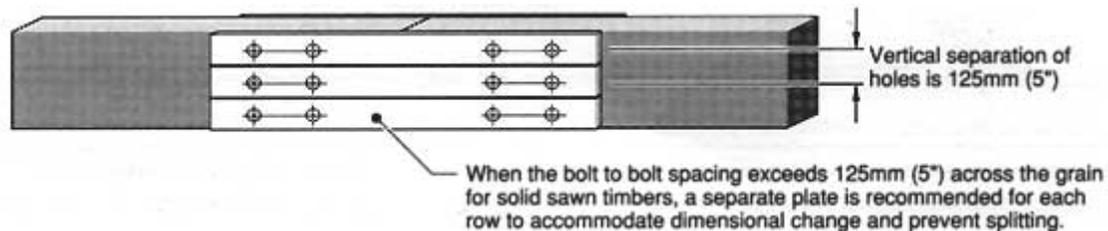
### Joint Spliced with Wood Side Members



### Joint Spliced with Steel Side Plates



### Joint Spliced with Multiple Steel Side Plates



# Lag Screws

Lag screws are bolts with sharp points and coarse threads designed to penetrate and grip wood fibre as shown in Figure 3 below. They are used to anchor metal, or wood, to wood in areas inaccessible to the placement of a nut for a throughbolt, or where an especially long bolt would be needed to penetrate a joint fully.

Although lag screws do have some unique applications, throughbolts are considered to be a more positive means of connection since they are less dependent on workmanship for reliable installation.

The resistance of a lag screw generally increases with the length of the embedded thread portion. However, it is also affected by other considerations such as side plate thickness.

As with other types of metal fasteners, sufficient end and edge distance must be provided to prevent splitting and to provide sufficient area for shear and bearing resistance in accordance with engineering design codes.

Stock sizes of lag screws range from 25 to 400mm (1" to 16") in length and 6 to 25mm (1/4" to 1") in diameter.

## Washers

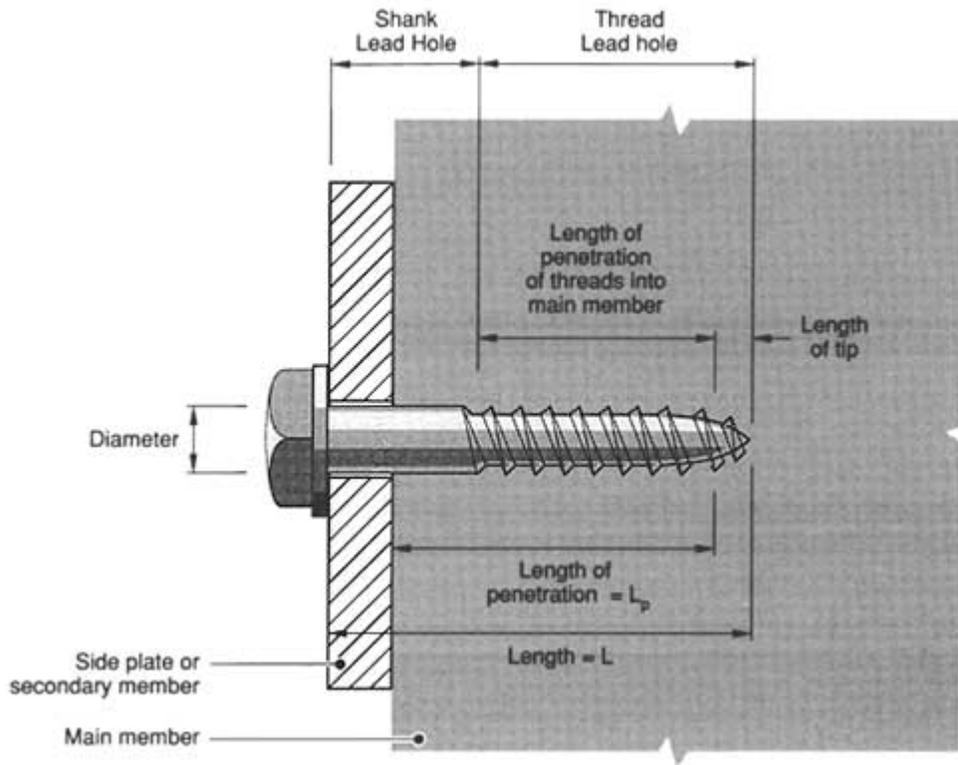
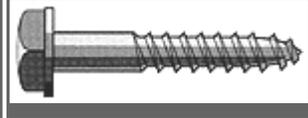
The same requirements for washers apply to those used with lag screws as to those used with bolts.

## Installation

Two hole diameters are used to prepare a member to accept a lag screw, drill bits of two dimensions must be used. The smaller diameter hole is drilled to accept the threaded portion of the lag screw, and a larger diameter hole is drilled to accommodate the shank portion.

**Figure 3: Lag Screws for Wood Construction**

Bolt Type	Usual Range of diameters		Uses
	mm	in.	
Lag Screw (Bolt)	6.4 to 25	1/4 to 1	In lieu of bolts where nut location would be inaccessible; sometimes used for split ring and shear plate joints



# Timber Rivets

## (also known as Glulam Rivets)

A timber rivet as shown in Figure 4 below, is a high strength fastener which resembles a nail but has a flattened oval shank with a wedge shaped head. The rivet is driven through pre-drilled holes in a steel side plate until the tapered head is wedged into the hole.

In Canada, timber rivets have become the fastener of choice for timber and glulam members because performance is proven, and machining for acceptance of bolts or split rings is eliminated.

The development of the timber rivet is the outcome of a long search for a new type of fastener particularly suited to laminated timber products. More than 40,000 rivets were tested either individually or in groups to determine capacities.

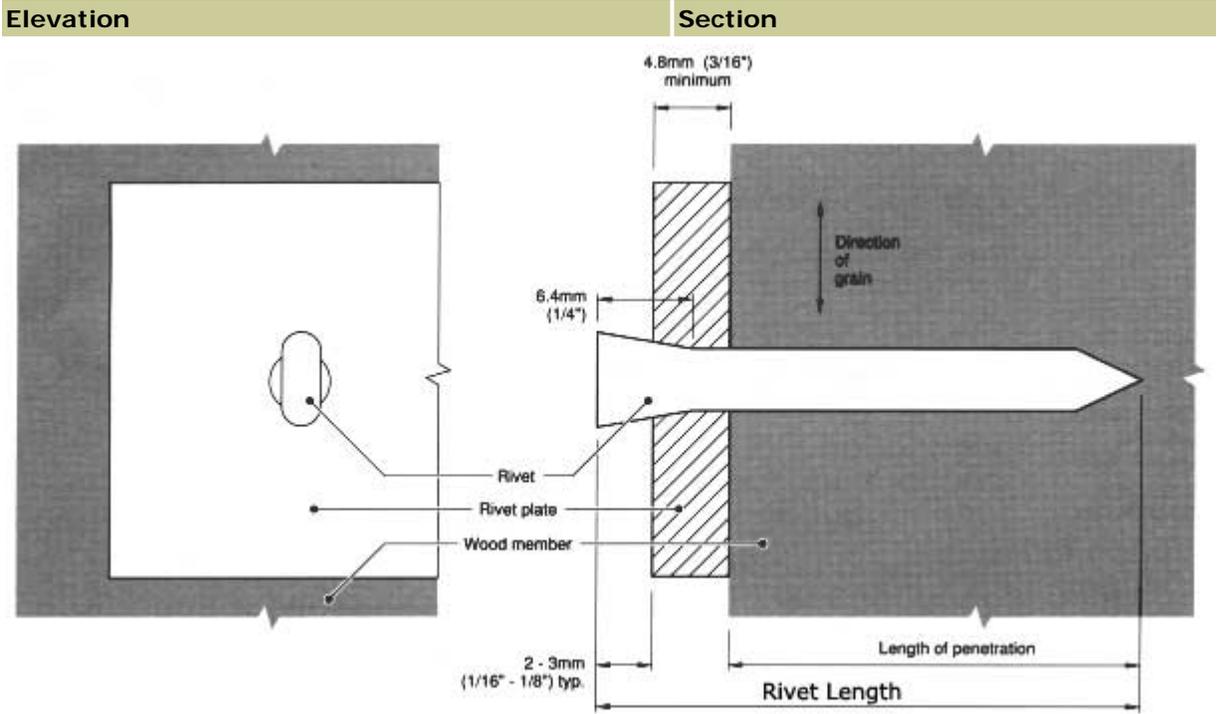
Timber rivets are used with both timber and Douglas Fir-Larch and Spruce-Pine glulam species.

Timber rivets are manufactured of heat-treated steel in lengths from 40mm to 90mm (1-1/2" to 3-1/2").

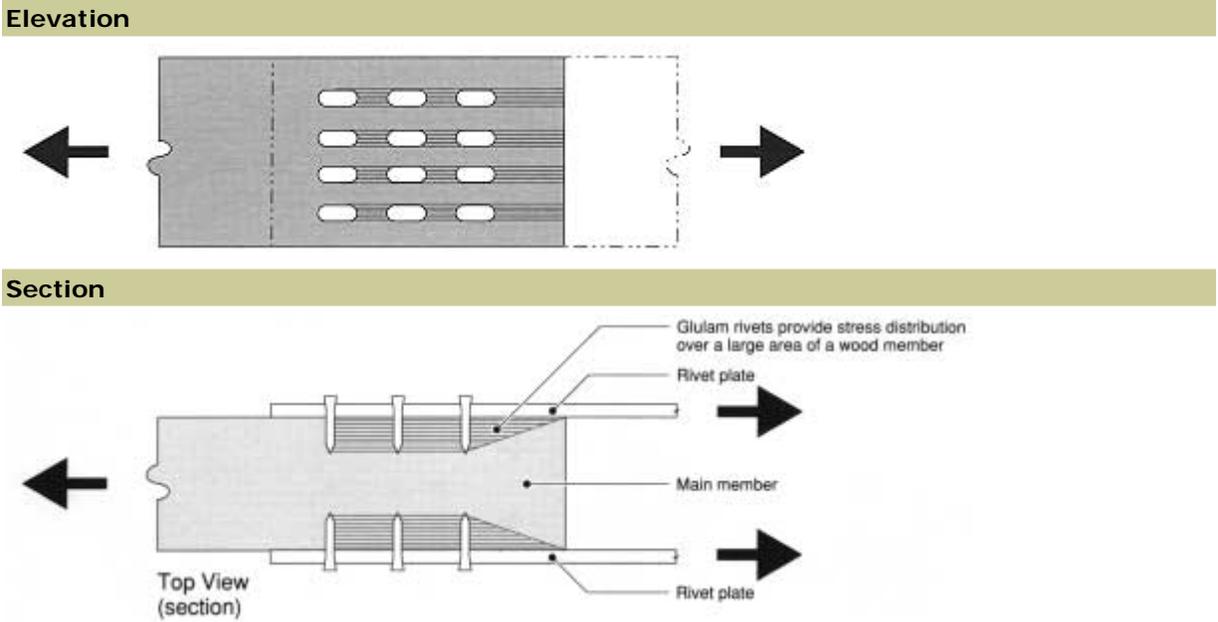
Steel plates used in conjunction with rivets must meet specific requirements for strength and ductility.

Timber rivets have numerous advantages over other fasteners such as bolts and shear plates. They permit a greater load transfer per unit contact area than any other fastener, resulting in substantial saving in the size of steel side plates. Reduction in glued-laminated member sizes are possible in some instances since member design can be based on the entire cross-sectional area rather than the net area remaining after removal of wood material for the installation of fasteners such as bolts and split rings. Field assembly is simplified and the chance of alignment error is reduced in comparison to other types of fasteners.

**Figure 4: Timber Rivets**



**Stress Distribution for Rivet Joint**



# Split Rings and Shear Plates

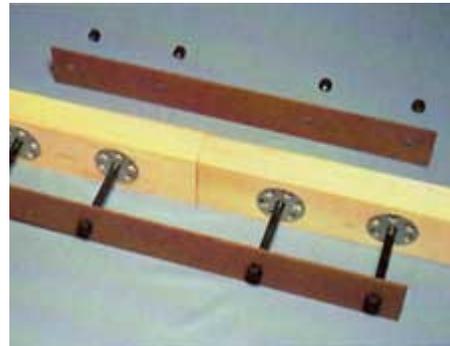
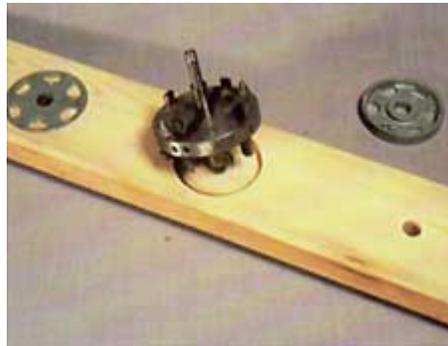
Split rings and shear plates are load transferring devices which rely on bolts or lag screws to restrain the joint assembly. They are more efficient structurally than bolts or lag screws used alone because they enlarge the wood area over which a load is distributed as shown in Figure 5 below.

Split rings and shear plates are used mainly to transfer loads in heavy timber or glulam members as in roof trusses. These connector units transfer shear either between the faces of two timber members or between a timber member and a metal side plate. They are not usually protectively coated and need be galvanized only if used with preservation treated wood or in wet service conditions.

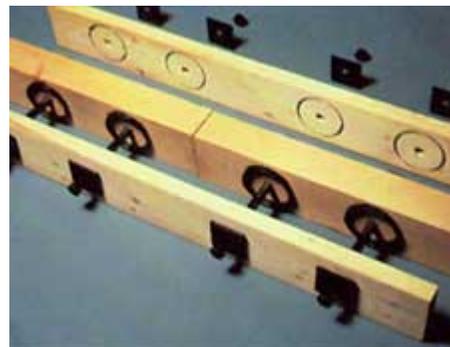
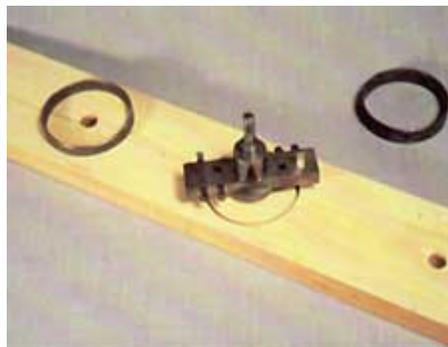
It is important that the proper size of bolt be used with a connector since it is an integral part of the assembly. The bolt clamps the joint together so that the connector acts effectively.

Split ring and shear plate joints are fabricated using the special tools as shown in the photographs below. Care must be taken to ensure a good fit.

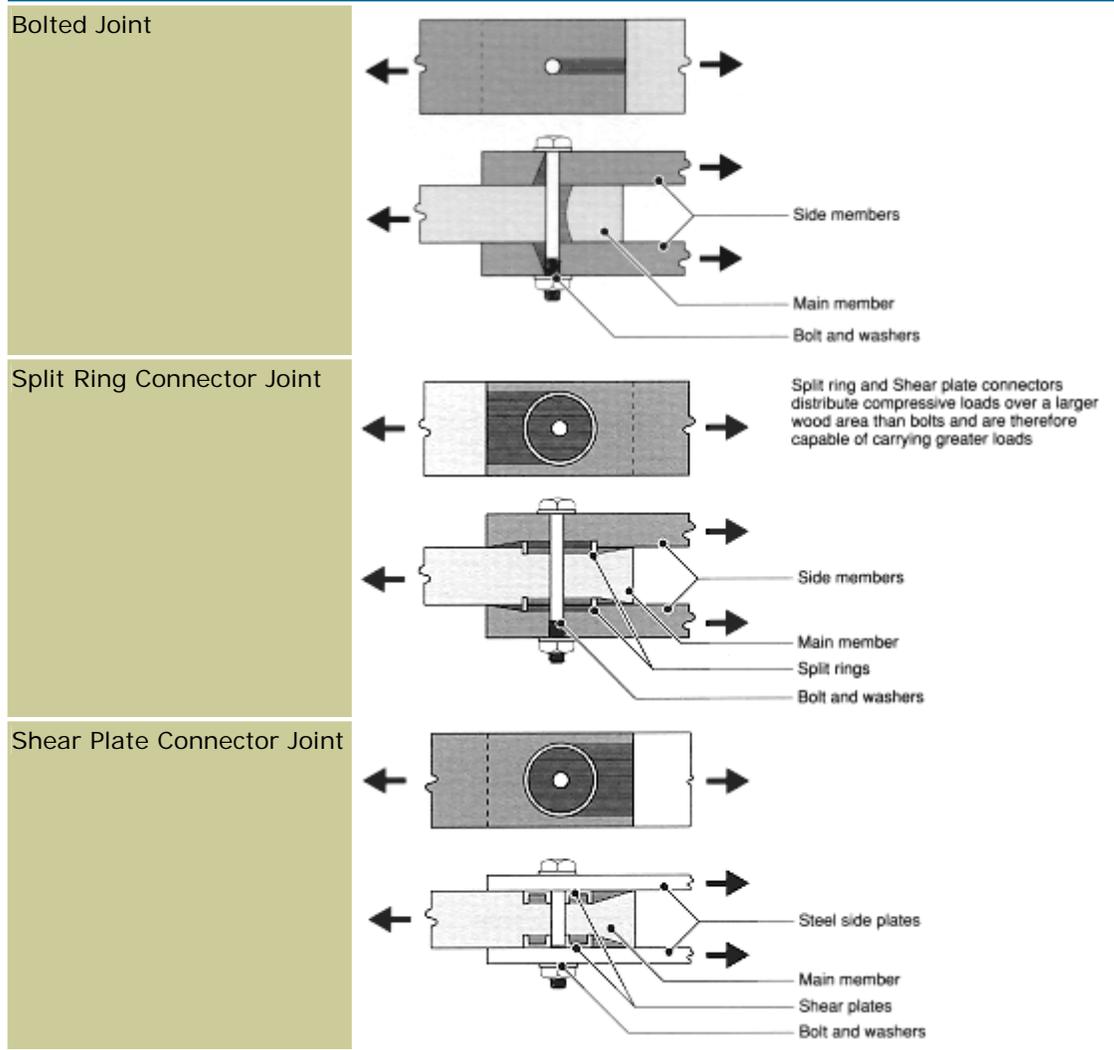
A special dapping tool is used for seating shear plates which are used with steel side plates.



Another dapping tool is used for seating split rings which are used with wood side plates.



**Figure 5: Stress Distribution for Bolted Joints with and without Split Rings and Shear Plates**



## Split Rings

Split rings are manufactured in Imperial sizes in diameters of 63mm (2-1/2") and 100mm (4") from hot-rolled carbon steel for use with 13mm (1/2") and 19mm (3/4") diameter bolts respectively.

A single split ring insets into both the precut grooves in the wood surface being joined as shown in Figure 6 below. A tongue and groove split in the ring permits the ring to deform slightly under load so that all contact areas distribute load, and the special wedge shape on both sides of the ring eases insertion and ensures a tight fitting joint when the ring is fully seated in the grooves.

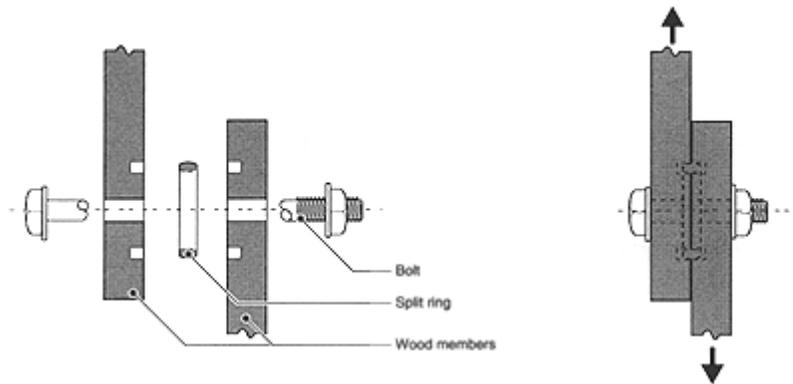
**Figure 6: Split Ring Loading Arrangements**

### Split Ring Connector

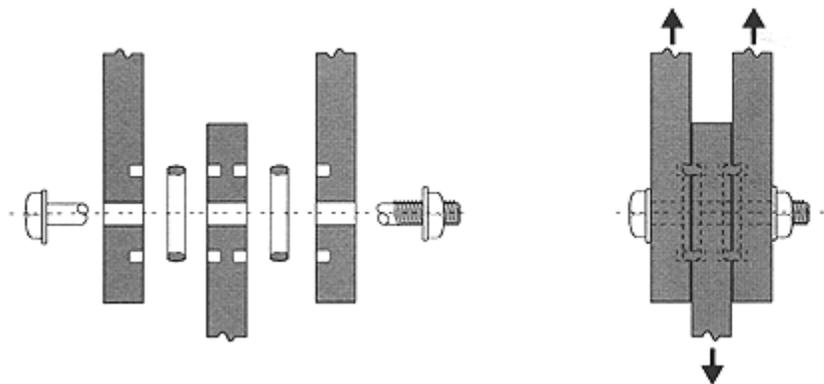
(Available in 63mm (2-1/2") and 100mm (4") diameters)



### One Split Ring - Bolt in Single Shear



### Two Split Rings - Bolt in Double Shear



## Shear Plates

Shear Plates are manufactured in Imperial sizes in a diameter of 67mm (2-5/8") in pressed steel for use with 19mm (3/4") bolts or lag screws, and in a diameter of 100mm (4") in malleable iron for use with 19mm (3/4") or 22mm (7/8") bolts or lag screws.

Grooves for shear plates must also be precision machined by special tools which recess the wood so that the shear plates sit flush with the surface.

Shear plates can be used singly to connect wood to steel, or be paired back to back to connect wood to wood as shown in Figure 7 below.

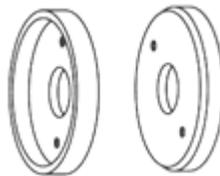
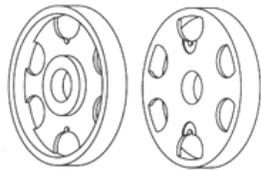
Typical wood-to-metal applications occur at purlin to beam, column to foundation, arch peak, and steel gusset connections.

Steel side plates used in conjunction with bolts must be sized according to wood engineering standards to resist tensile and compressive forces as well as buckling at critical sections.

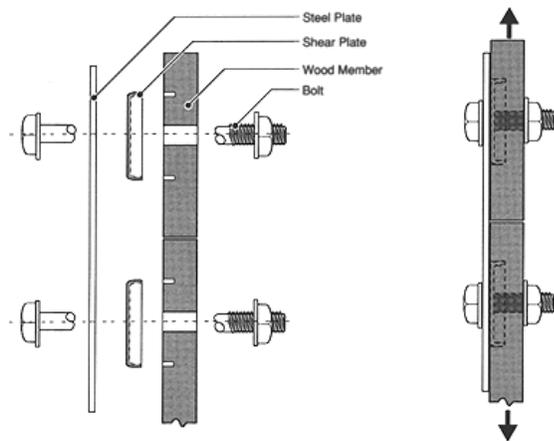
**Figure 7: Shear Plate Loading Arrangements**

**Malleable Iron Shear Plates**  
(Available in 100mm (4") diameter)

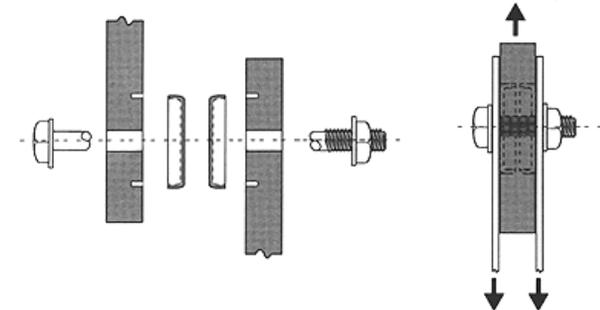
**Pressed Steel Shear Plates**  
(Available in 67mm (2-5/8") diameter)



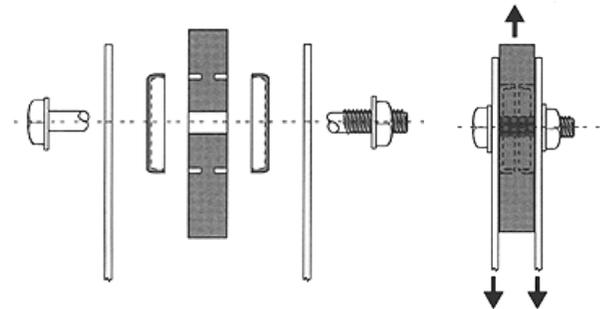
**One Shear Plate - Bolts in Single Shear**



**Two Shear Plates - Bolt in Single Shear**



**Two Shear Plates - Bolt in Double Shear**



## General Guidelines for Connections

- Standardize fasteners on a project to speed installation and to reduce the chances of error.
- Select a fastener material or finish which suits the moisture conditions.
- Design connection details to accommodate seasoning effect as moisture level in the wood product adjusts to the building environment.
- Specify a finished appearance which suits visual prominence of the fasteners.
- Connection design must respect wood end and edge distance setbacks to ensure adequacy.
- Connection design must provide stipulated distances between connectors. Ensure that adequate wood material remains after boring for connectors to transfer forces.
- Fastener capacity varies with the in service moisture content of wood. Most building applications will be for dry service conditions which give good fastener capacity values.

## References

*TTS Wood Trusses*  
Jaeger Industries Inc., Calgary AB

*Wood Design Manual*  
Canadian Wood Council

*Wood Engineering and Construction Handbook*  
Keith E. Flaherty and Thomas G. Williamson, McGraw Hill Publishing, 1989

*Wood Handbook: Wood as an Engineering Material*  
United States Department of Agriculture, Agriculture Handbook 72, 1987

## Links

Cleveland Steel

GRK Fasteners Ltd.

MGA Connectors

TIMBERLINX

Timber Systems Limited