MyTiCon Timber Connectors White Paper

Full Thread Screw Connection Cost Efficiency

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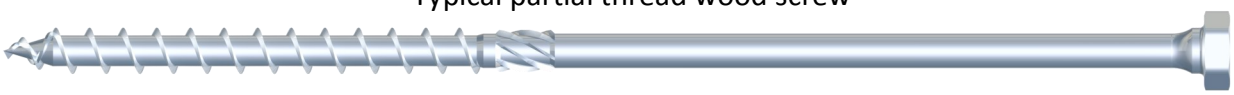
Introduction

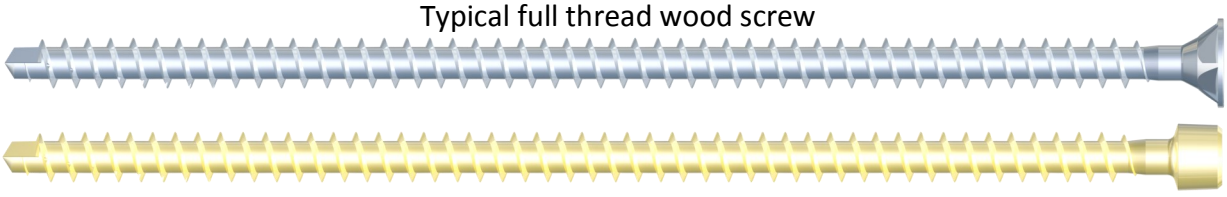
Full thread screw technology has been used across Europe for the past 10 years. In early 2014 the first code approval in Canada for full thread screws was issued under CCMC 13677-R. The CCMC report allows engineers to use full thread screws in load bearing connections where wood members are connected to other wood members or wood members are connected to steel elements. The design procedures consider common shear connections where the forces are perpendicular to the fastener axis. The suggested design procedures follow the European Johansen Yield Model. Traditionally, for common shear connections, structural screws with partial thread are used. Due to the intended failure modes of wood crushing and fastener yielding limited capacity and stiffness is observed. Utilising structural full thread wood screws in tension as opposed to shear action creates new design opportunities of high performance connection systems.

With the topic of Mass Timber or Tall Wood Structures connection requirements are increasing and cost efficiencies are important to consider. In this White Paper a cost comparison between fasteners in shear and fasteners in tension is provided considering several fastener arrangements. Furthermore the application of structural accessories such as 45° washers in steel to wood connections is considered.

Typical partial thread wood screw



Typical full thread wood screw



Typical 45° wedge washer connector

Fastener Facts 10mm (3/8") Lag Screw

Shank diameter: 9.5mm (3/8")

Bending yield strength: f_y = 310Mpa (as per CSA 086)

Pre-drilling requirements: 1 hole for the shank ≈ 3/8"

1 hole for threads ≈ 1/4"

Available common length: 300 mm (12")

Installation tool as per CSA 086: turning with a wrench

Fastener Facts 12mm (1/2") SWG ASSY KOMBI Screw

Shank diameter: 8.2mm (5/16")

Bending yield strength: f_y = 1147Mpa (as per CCMC13677-R)

Pre-drilling requirements: Not required

Available common length: 520mm (20.5")

Installation tool as per CCMC: power tools , high torque low rpm

Fastener Facts 10mm (3/8") Lag Screw

Shank diameter: 9.5mm (3/8")

Bending yield strength: f_y = 310Mpa (as per CSA 086)

Pre-drilling requirements: 1 hole for the shank ≈ 3/8"

1 hole for threads ≈ 1/4"

Available common length: 300 mm (12")

Installation tool as per CSA 086: turning with a wrench

Fastener Facts 10mm (3/8") SWG ASSY VG CSK

Shank diameter: 6.2mm (1/4")

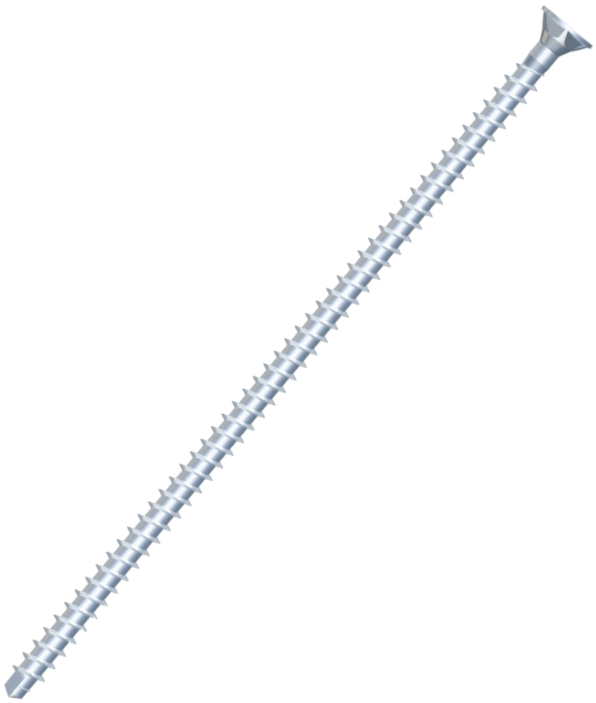
Bending yield strength: f_y = 942Mpa (as per CCMC13677R)

Factored tensile resistance: 19.2kN

Pre-drilling requirements: Not required unless specified

Available common length: 800mm (31.5")

Installation tool as per CCMC: power tools, high torque low rpm



Wood to Wood Connection Example 3/8” Lag Screw vs 1/2” SWG ASSY Kombi

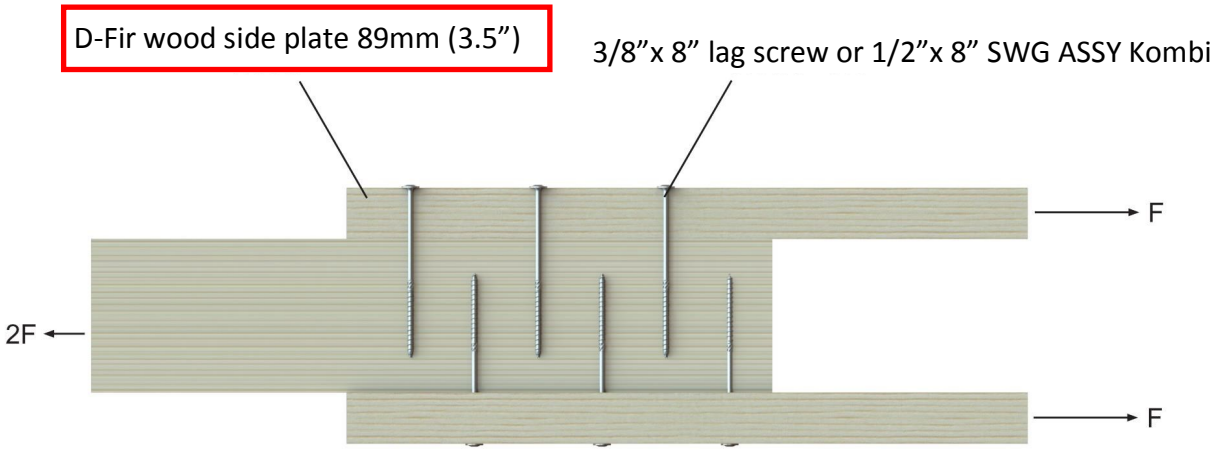


Table 1: Lag screw vs. SWG ASSY® Kombi partial thread screw for Wood to Wood connection

Lag screw vs ASSY® screw - Wood to Wood				
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P’r [kN]	**ASSY Kombi screw with 44% higher capacity**
Lag screw	**200**	**9.5**	**2.6**	
SWG ASSY® Kombi	**200**	**8.2**	**3.74**	

Wood to Steel Connection Example 3/8” Lag Screw vs 1/2” SWG ASSY Kombi

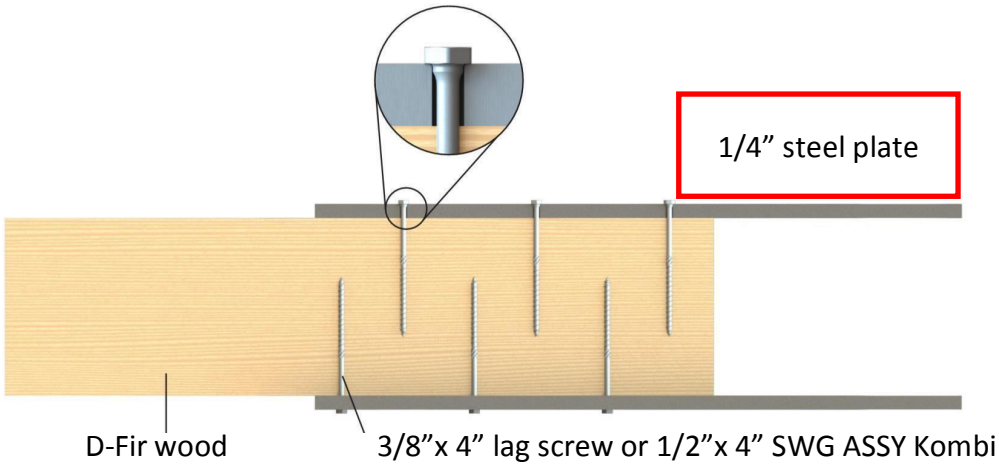


Table 2: Lag screw vs. SWG ASSY® Kombi partial thread screw for Wood to Steel connection

Lag screw vs ASSY® screw - Wood to Steel				
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P’r [kN]	**ASSY Kombi screw with 45% higher capacity**
Lag screw	**100**	**9.5**	**3.6**	
SWG ASSY® Kombi	**100**	**8.2**	**5.25**	

Wood to Wood Connection Example 3/8” Lag Screw vs 3/8” SWG ASSY VG Full Thread

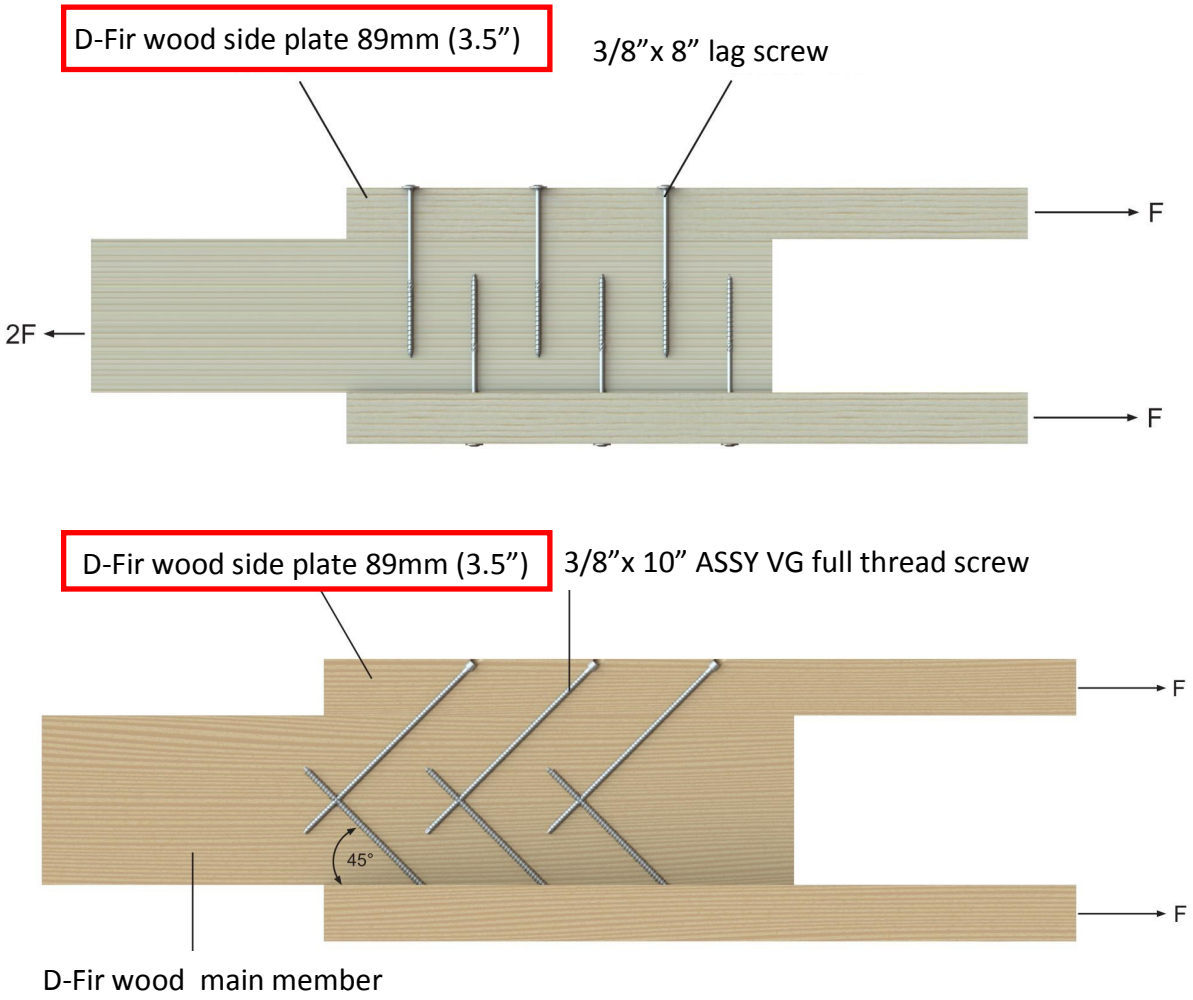


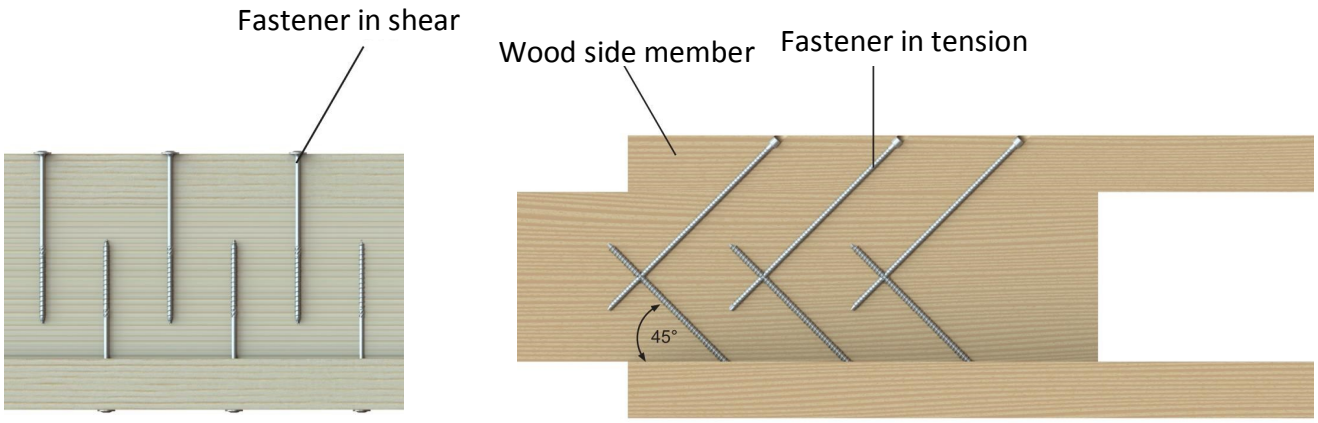
Table 3: Lag screw vs. SWG ASSY VG full thread screw for Wood to Wood connection

Lag screw vs ASSY VG full thread screw - Wood to Wood				
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P’r [kN]	**ASSY VG full thread screw with 170% higher capacity**
Lag screw	**200**	**9.5**	**2.6**	
SWG ASSY® VG full thread screw	**240**	**6.2**	**6.96**	

With increasing side member thickness fastener length must increase for fasteners in shear and fasteners in tension. However for fasteners in shear action where fastener yielding and wood crushing is intended to control the design connection capacities are limited.

Using the screws strongest property i.e. the withdrawal resistance, allows for much higher connection capacities. The upper boundary, the tensile resistance of the screw must be considered.

In wood to wood connections the higher cost of full thread wood screws in tension is accounted for through a much higher capacity. Therefore, from a fastener cost point of view, full thread screws in tension work at higher cost efficiencies.



Wood to Steel Connection Example 3/8” Lag Screw vs 3/8” SWG ASSY VG Full Thread

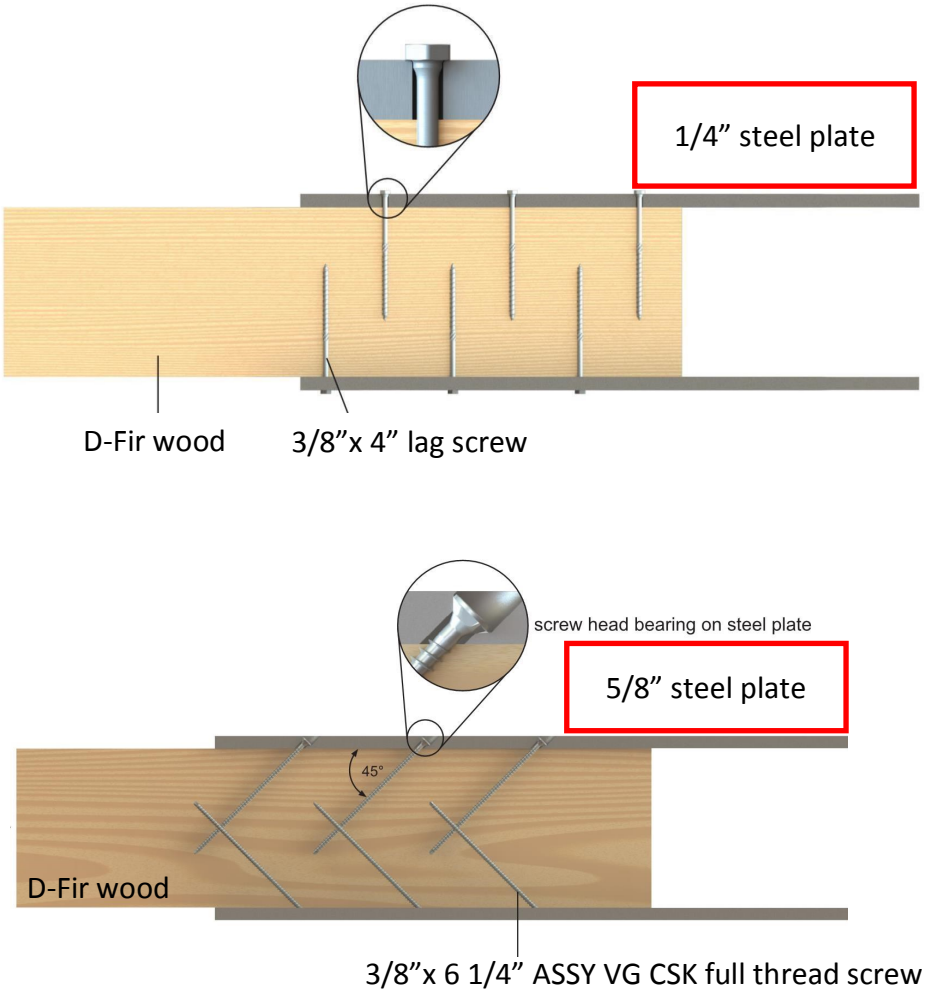
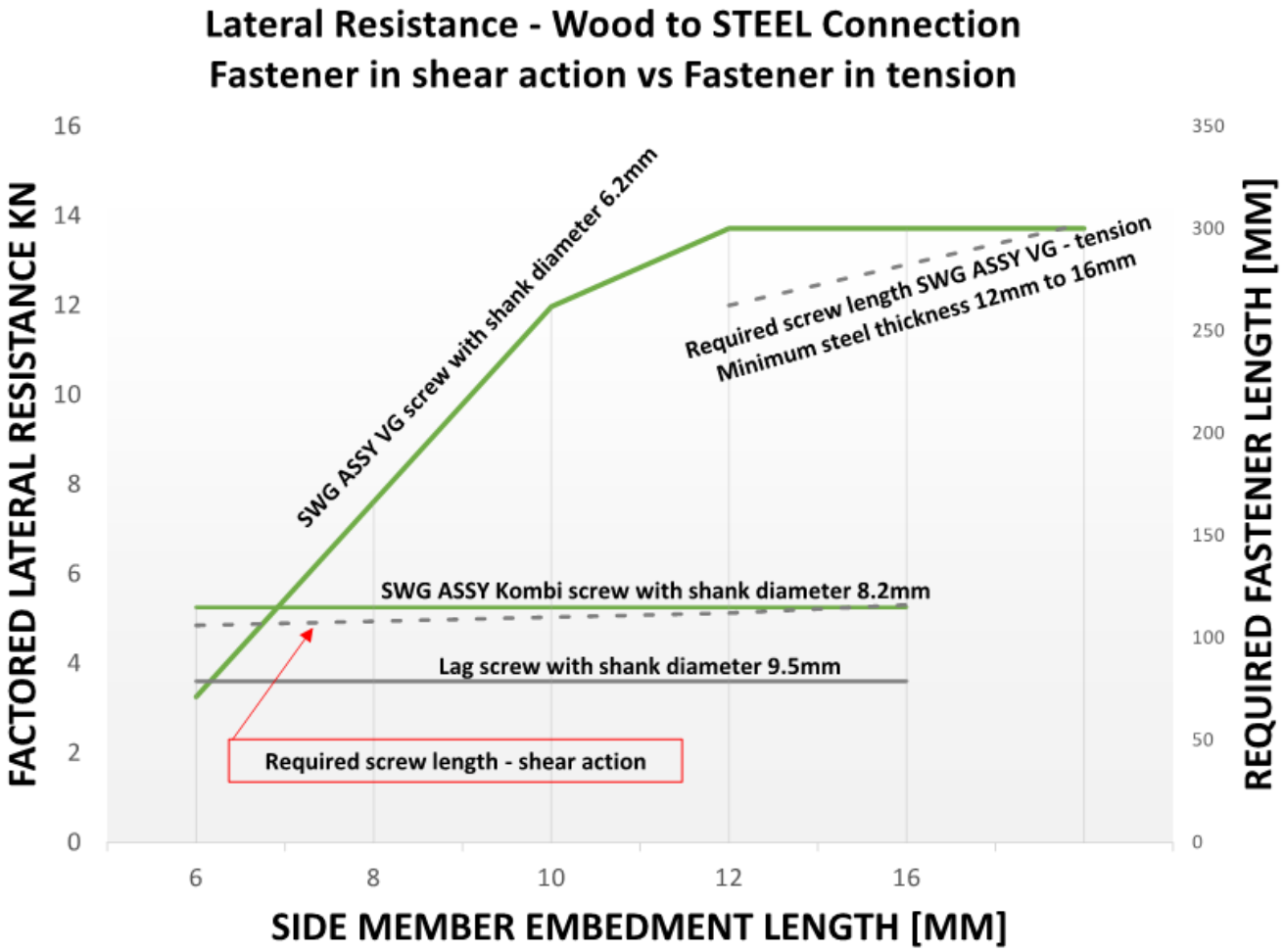


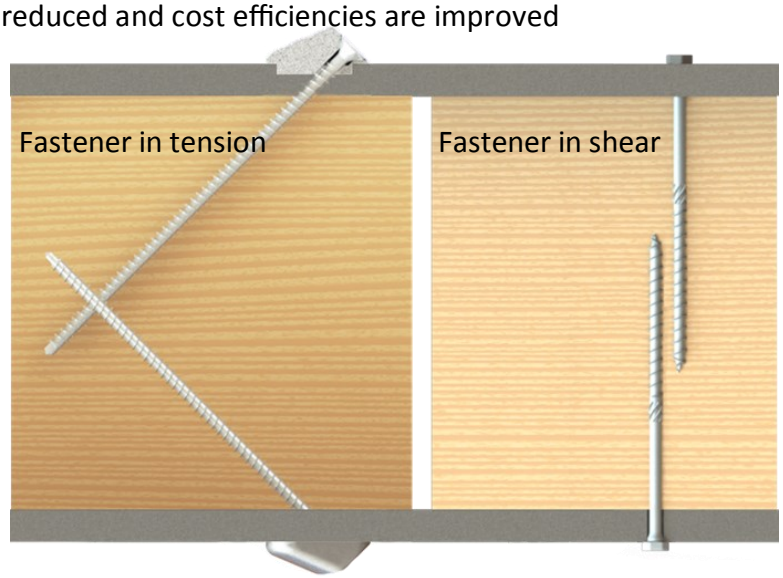
Table 4: Lag screw vs. SWG ASSY® VG CSK full thread screw for Wood to Steel connection

Lag screw vs ASSY® VG CSK full thread screw - Wood to Steel				
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P’r [kN]	**ASSY VG full thread screw with 115% higher capacity**
Lag screw	**100**	**9.5**	**3.6**	
SWG ASSY® VG full thread screw	**160**	**6.2**	**7.8**	



In wood to steel connections the capacity of fasteners in shear action is controlled by the intended failure mode of fastener yielding and wood crushing. With a relatively short fastener embedment length of approximately 8d (where d= fastener diameter) the design connection capacity may be reached. Once the fastener yields or the wood crushes at the shear plane increased fastener length does not increase capacity. Using full thread wood screws on an angle to the wood grain however allows to increase the connection capacities far beyond the capacity of fasteners in shear. Depending on the length of the full thread fasteners and their respective tensile resistance up to 5 times higher capacities may be achieved.

The application of full thread wood screws on an angle to the wood grain offer high connection capacities through relatively short fasteners. Therefore the cost per kN of capacity is reduced and cost efficiencies are improved



Wood to Steel Connection Example 3/8" ASSY VG CSK vs 3/8" ASSY VG CSK with Washer

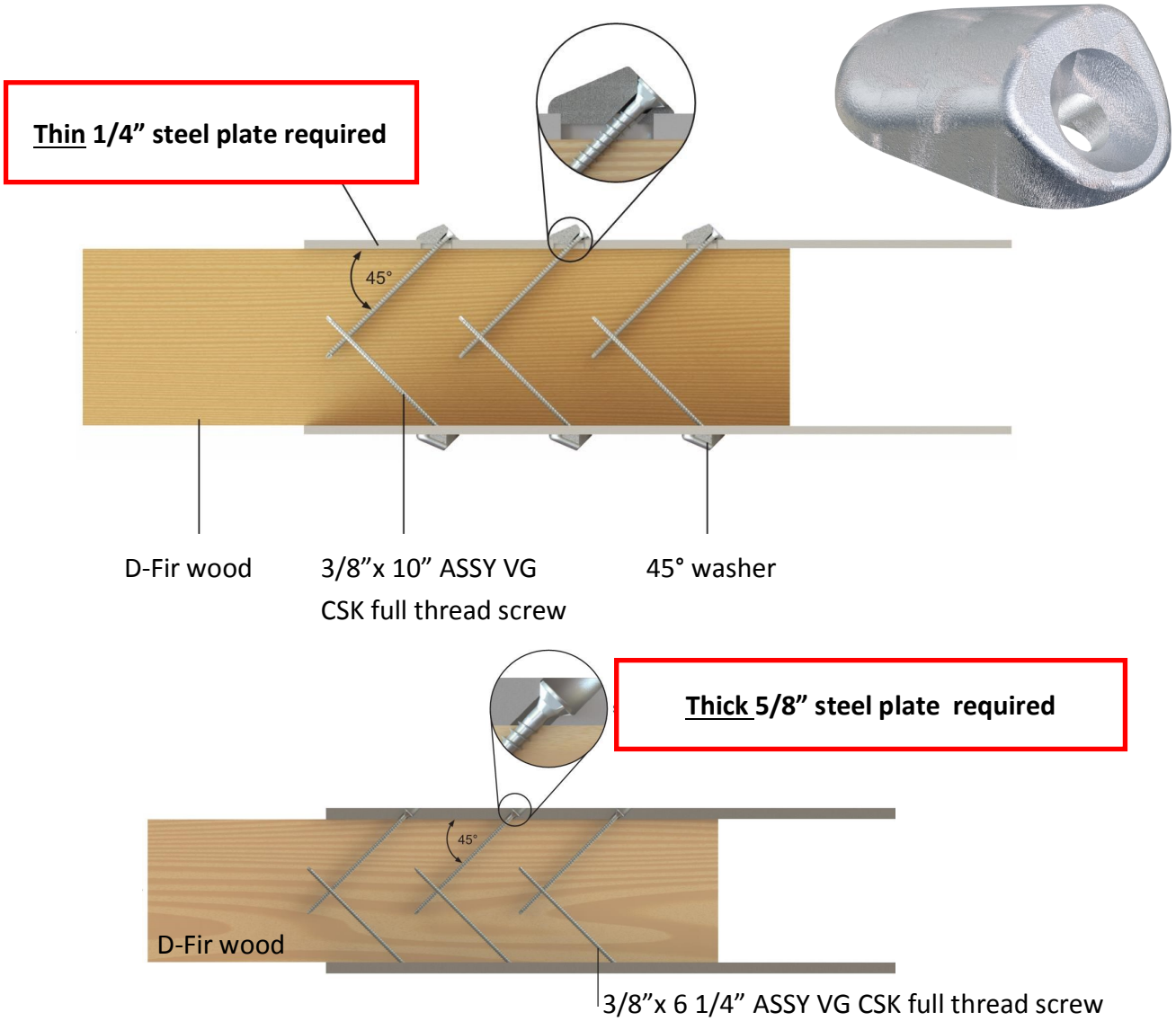


Table 5: Lag screw vs. SWG ASSY® VG CSK full thread screw for different Wood to Steel connection assemblies

Lag screw vs ASSY® VG CSK full thread screw - Wood to Steel					
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P'r [kN]	Steel plate thickness	Hole
Lag screw	**100**	**9.5**	**3.6**	**1/4"**	**punched**
SWG ASSY® VG full thread screw with washer	**160**	**6.2**	**7.3**	**1/4" plus 100% more capacity**	**punched**
SWG ASSY® VG full thread screw	**160**	**6.2**	**7.8**	**5/8" plus 120% more capacity**	**milled (expensive)**

Cost Savings for ASSY VG CSK Screws with 45° Washers in Steel to Wood Connections

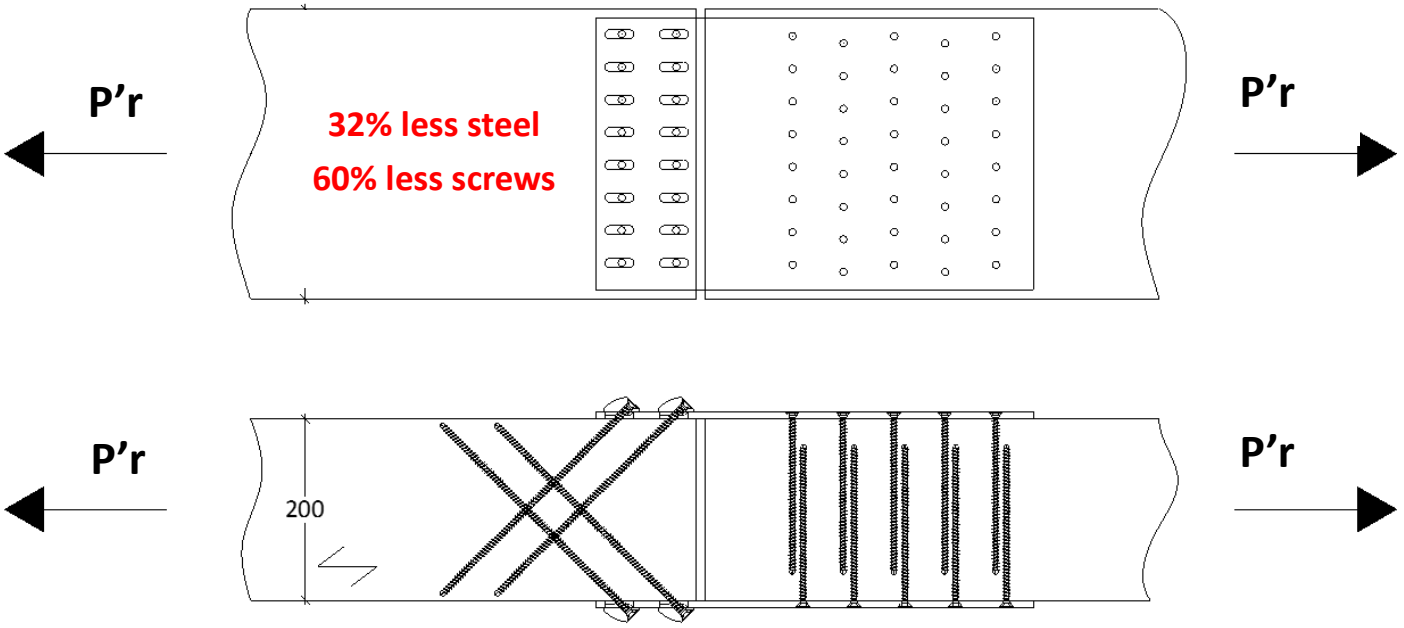
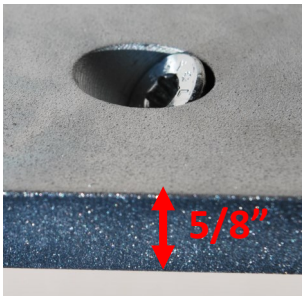


Table 6: Lag screw vs. SWG ASSY® VG CSK full thread screw example in Wood to Steel connection

Lag screw vs ASSY® VG CSK full thread screw - Wood to Steel				
Fastener type	Fastener length [mm]	Shank diameter [mm]	Factored lateral resistance P'r [kN]	Estimated connection capacity [kN]
Lag screw	**200**	**9.5**	**3.6**	**288**
SWG ASSY® VG full thread screw with washer	**280**	**6.2**	**13.7**	**438**

In summary one can find that the application of full thread wood screws in tension applications i.e. under an angle to the wood grain yields better cost efficiencies when compared to common connections with fasteners in shear action. The reason for this can be found in the fact that withdrawal resistances outperform shear resistances by far until the tensile resistance of the screw steel is reached. Screws loaded in withdrawal can outperform fasteners in shear even if only a short thread embedment depth can be provided.

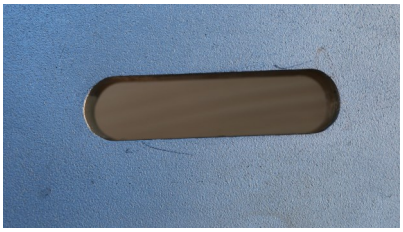
Cost Savings for ASSY VG CSK Screws with 45° Washers in Steel to Wood Connections



Typical machining requirement in steel plate to accommodate structural screw

High fabrication cost and specialty machinery required

Thick 5/8” steel plate required to house screw head



Simple punched hole

Thin steel plate 1/4”

Pre drill jig for fast, accurate install angle

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