MyTiCon Timber Connectors

Webinar Sessions: Basics of Lateral Connection Design

About the presenter:

Tobias Eberwein

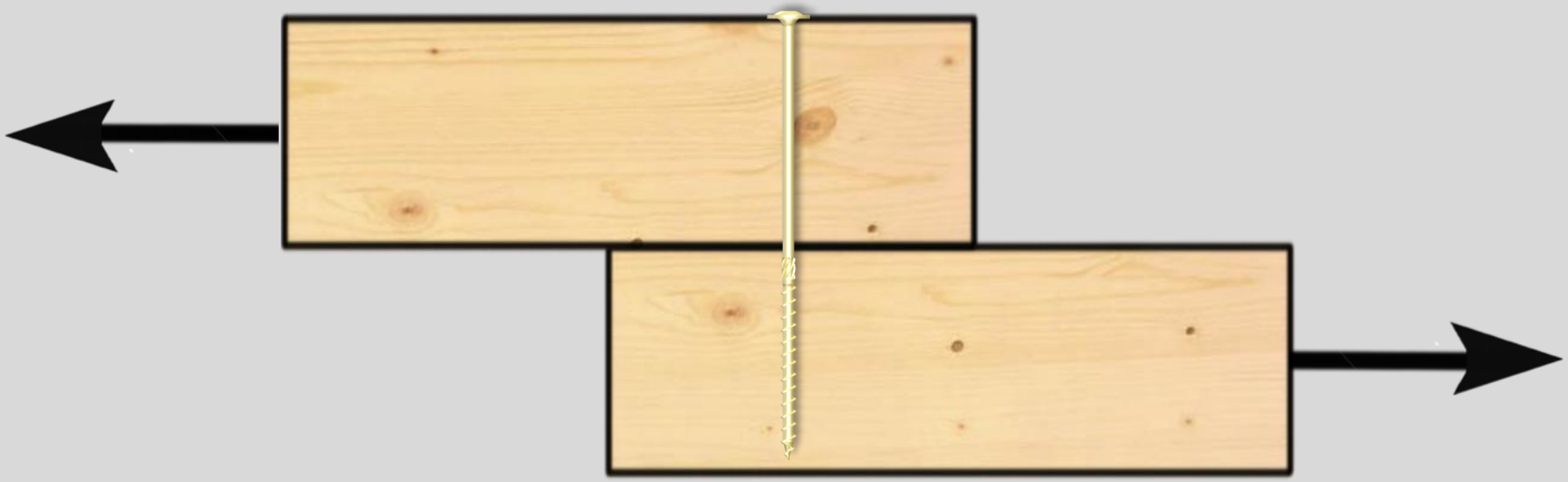
- B.Eng. in Timber Engineering

- Technical Support Engineer
  at MyTiCon Timber Connectors

Agenda:

- Historical background of lateral design
- Modern base concepts
- Comparison of different design codes

Basics of Lateral Connection Design



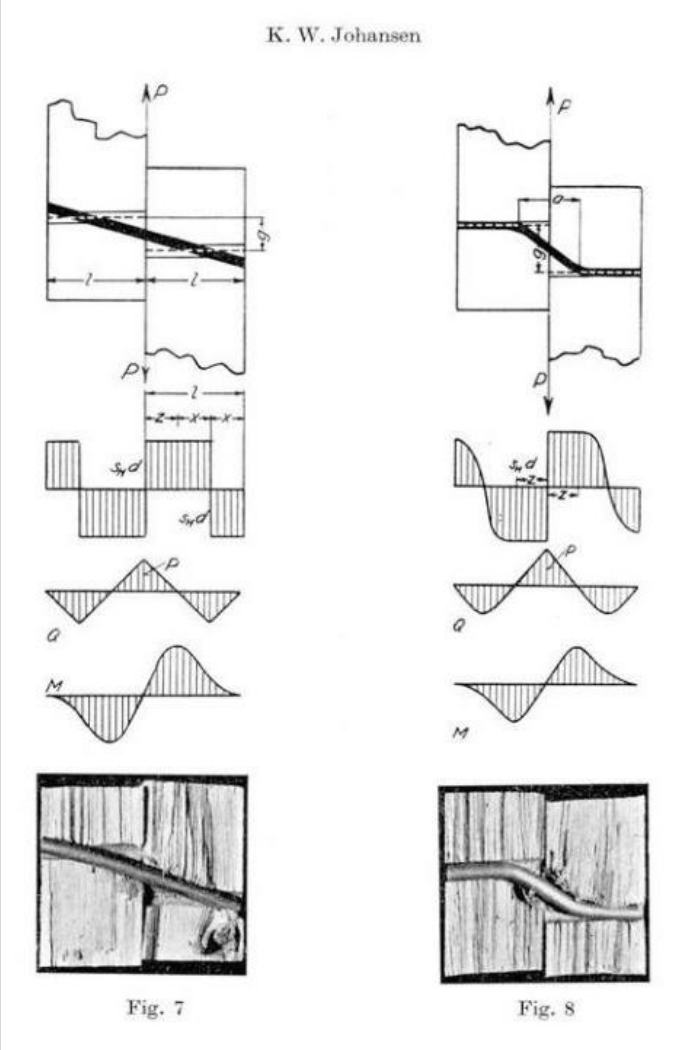
The EYM (European Yield Model)

Based on the work of K.W. Johansen

Theory of Timber Connections (1949)

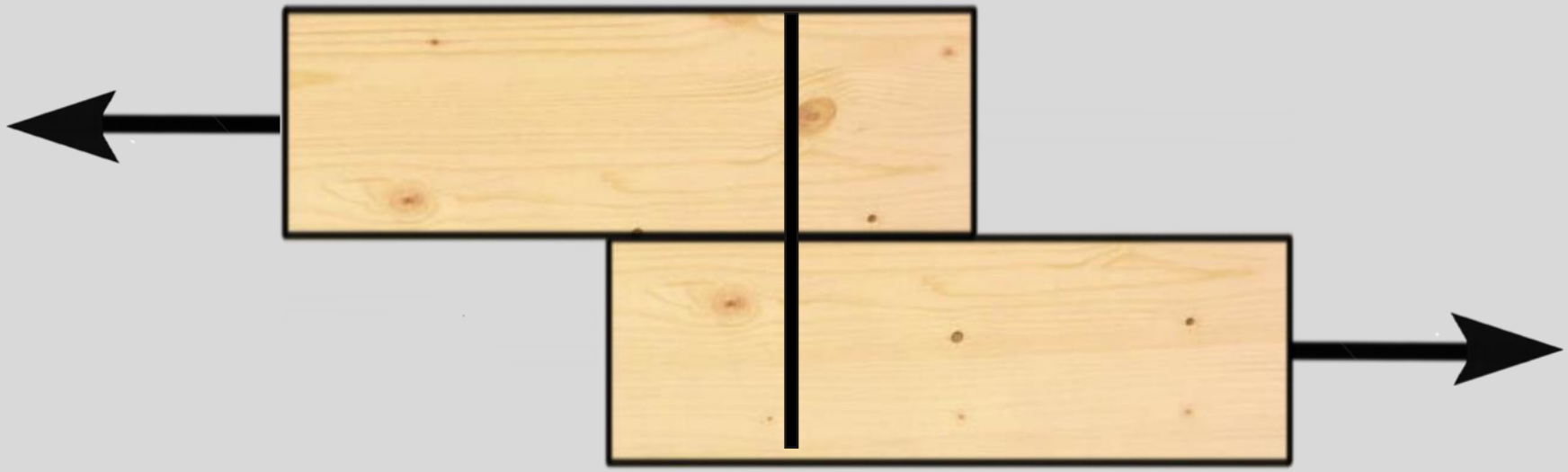
3 elementary effects:

- Dowel effect of fastener (bending & wood crushing)
- Effects of the wood (crushing resistance, grain direction, wood species)
- Axial effect of the bolt



Source: Theory of timber connections; Johansen (1949)

Basics of Lateral Connection Design



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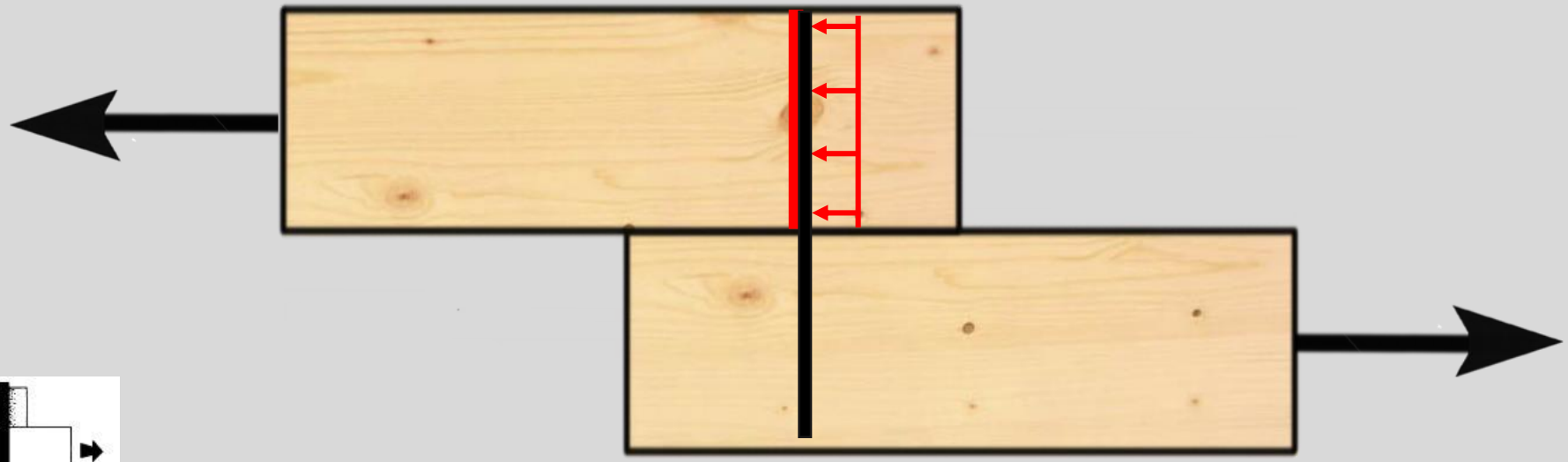
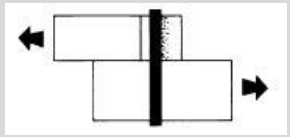
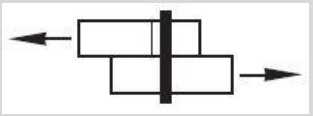


Failure Mode:

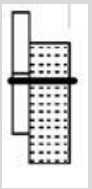
I_s



(a)



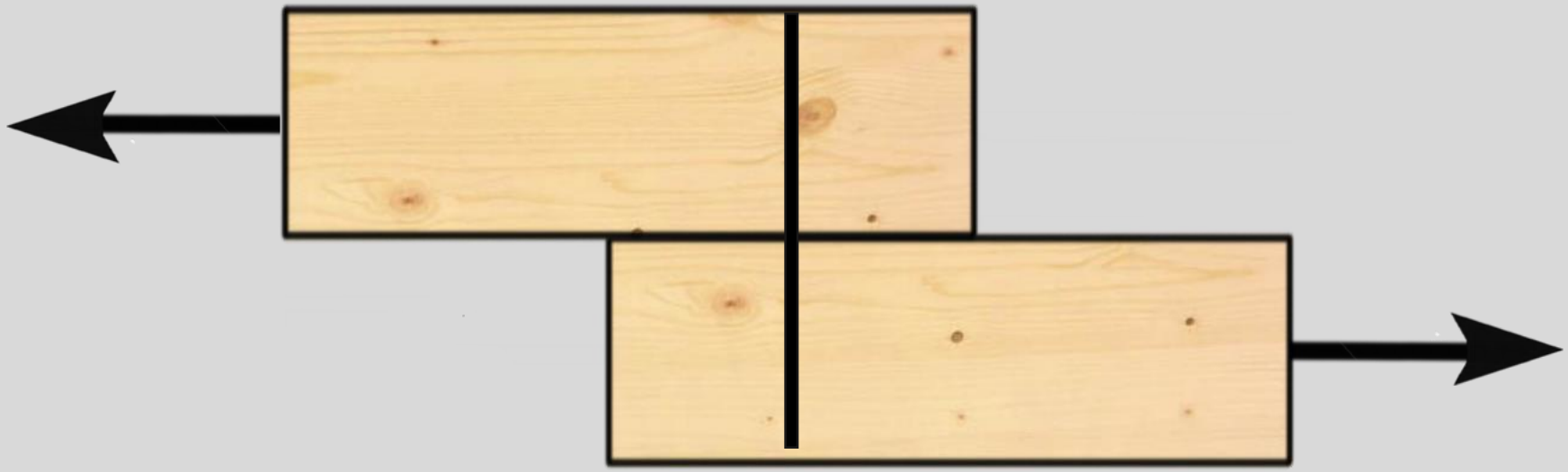
a



Possible Reasons:

- Thin side member
- Large diameter fastener
- Low density wood

Basics of Lateral Connection Design



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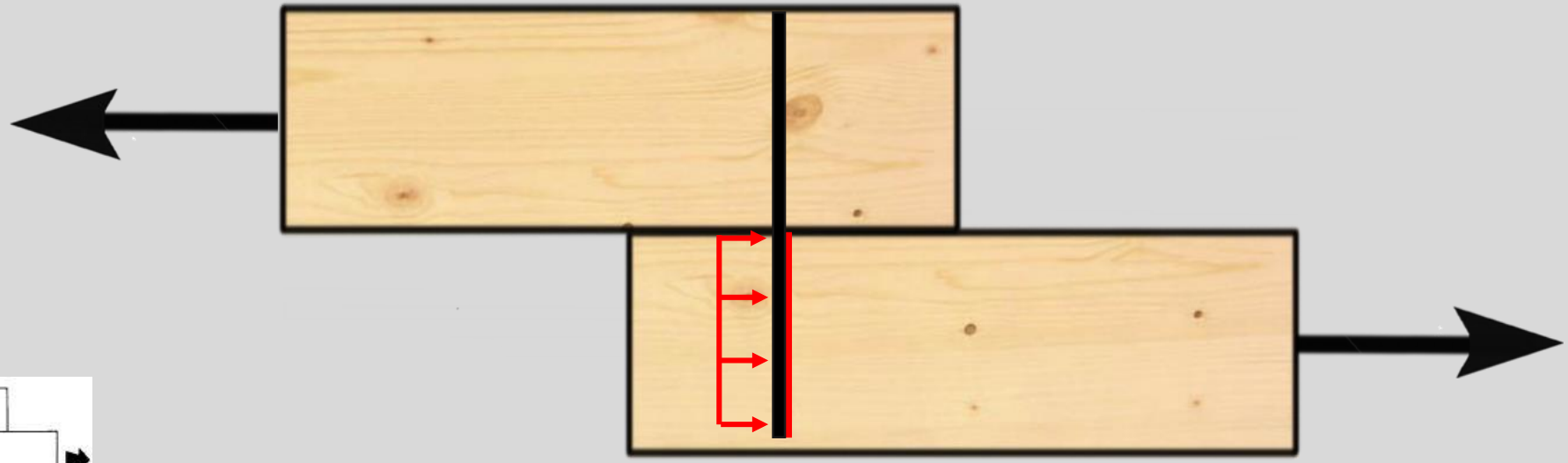

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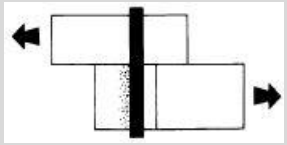

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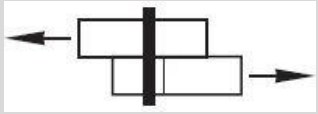

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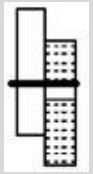

Possible Reasons:

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- Large diameter fastener
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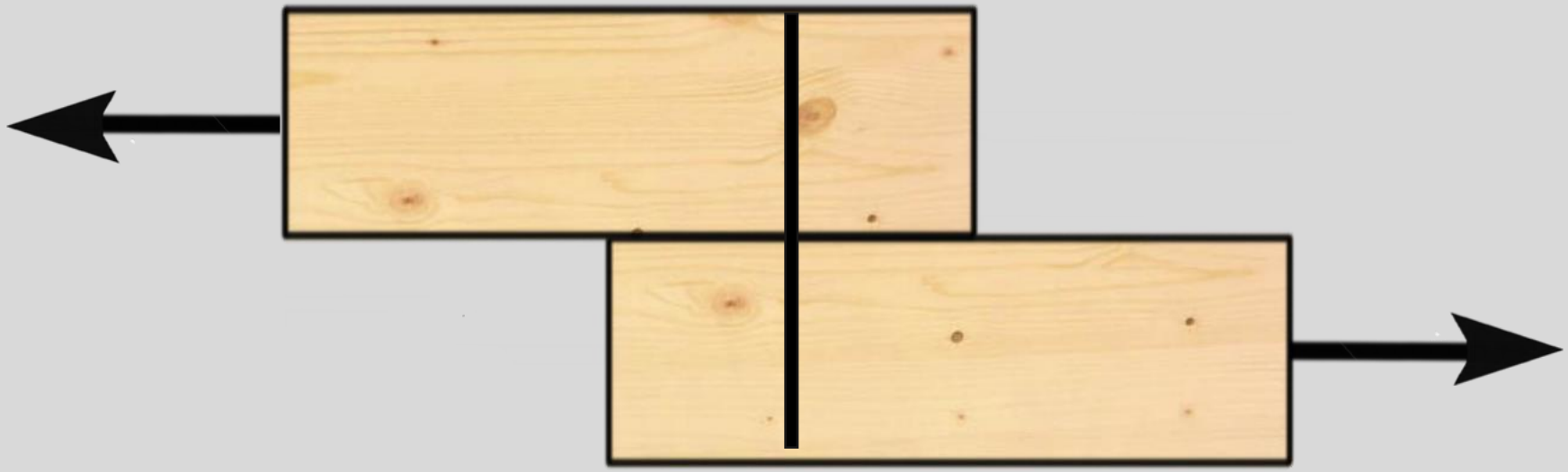

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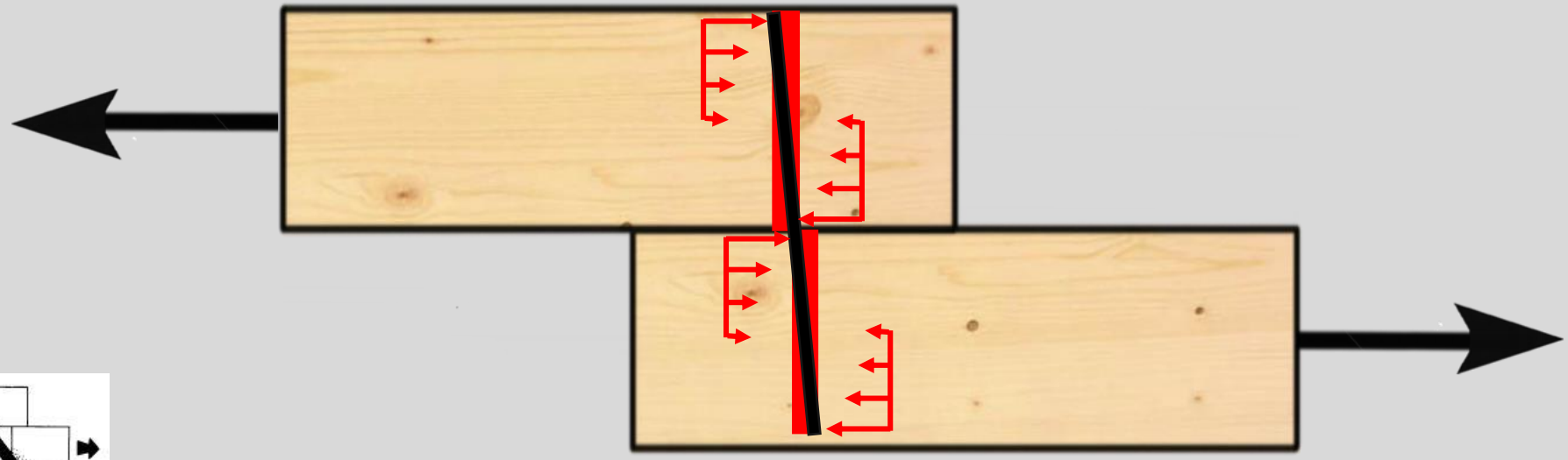
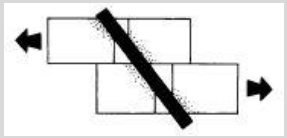
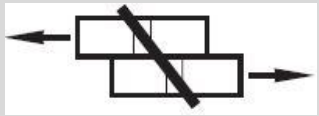


Failure Mode:

II



(f)

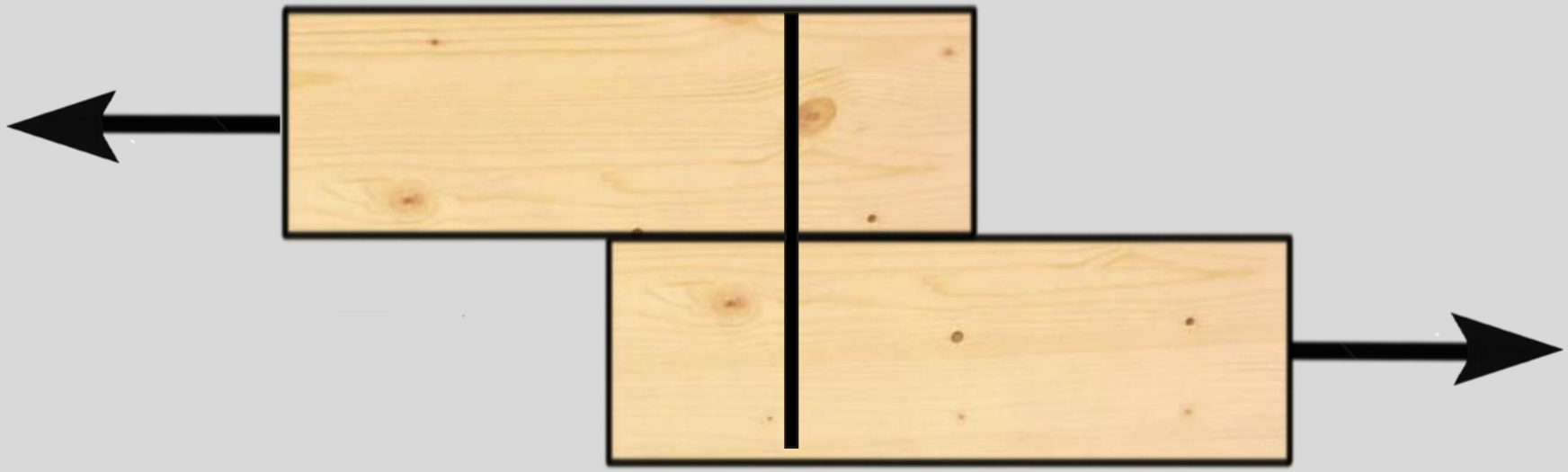


c

Possible Reasons:

- Thin side and main member
- Large diameter fastener
- Low density wood

Basics of Lateral Connection Design



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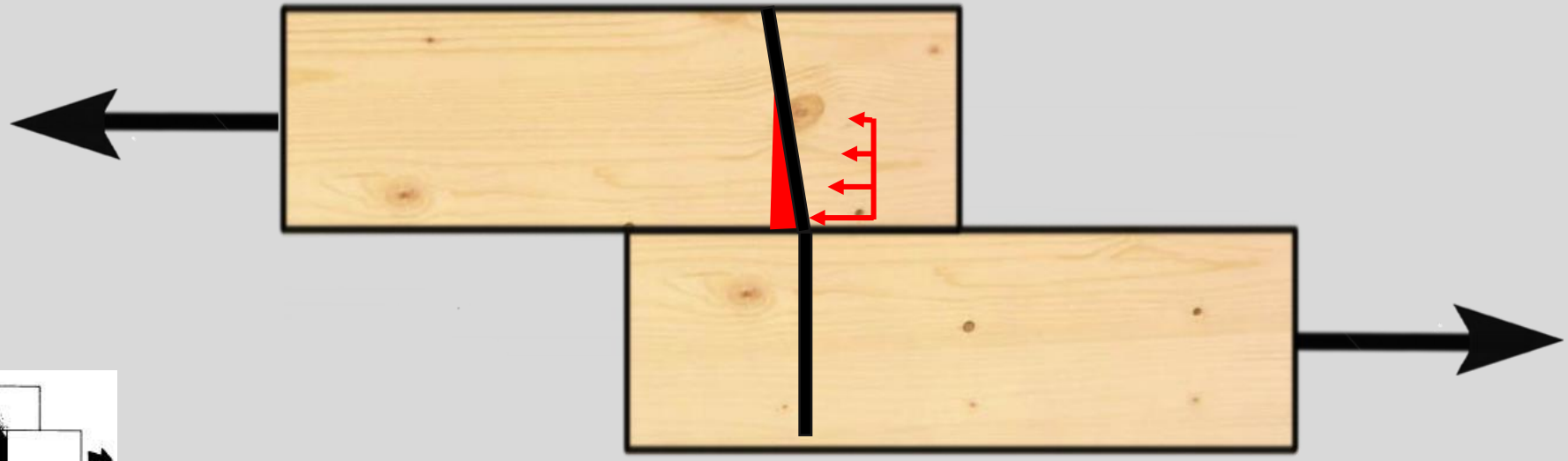

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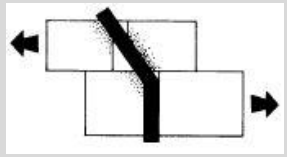
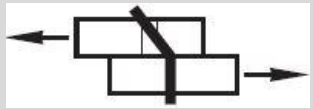
III_s



(d)



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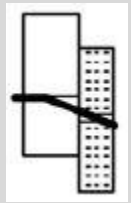

Possible Reasons:

- Longer embedment lengths
- Small diameter fastener
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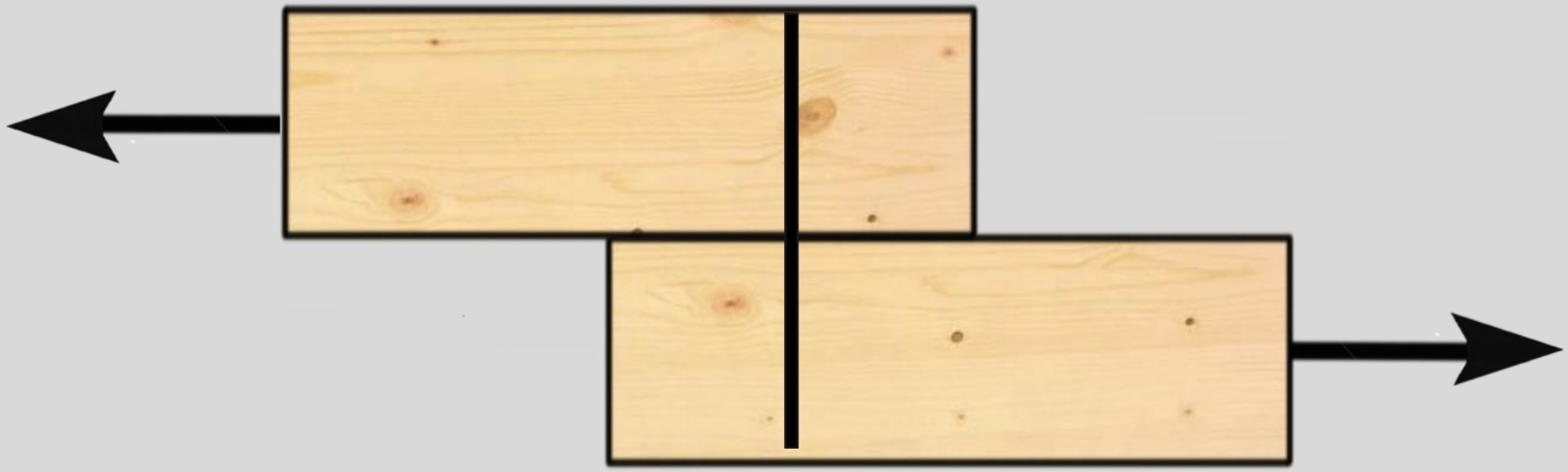

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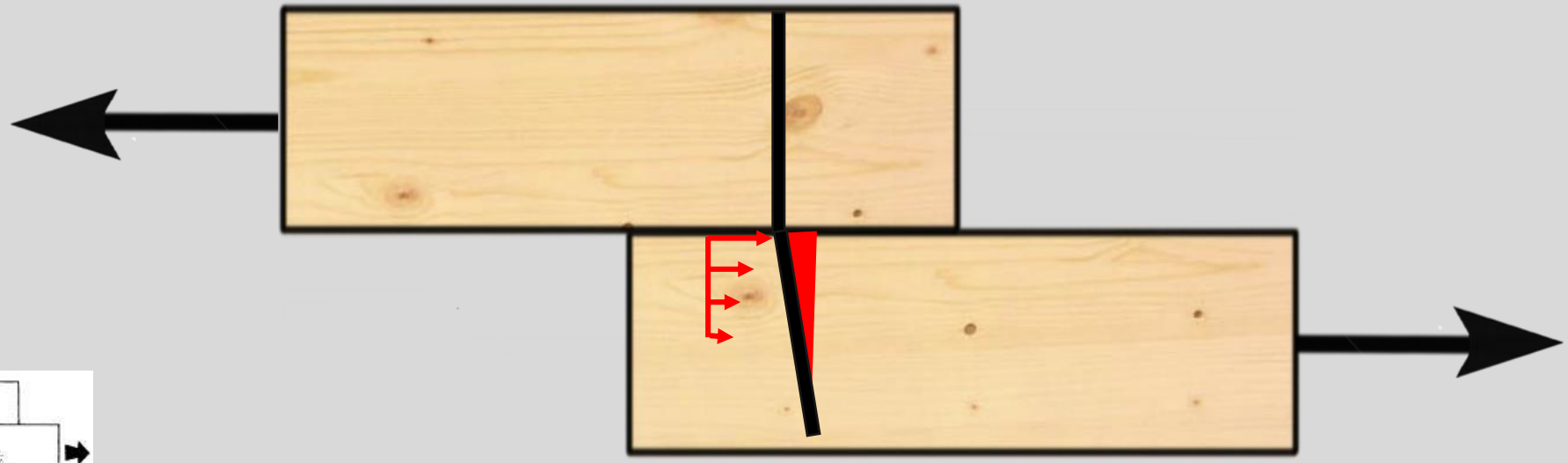

Failure Mode:

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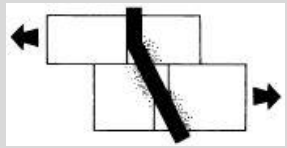

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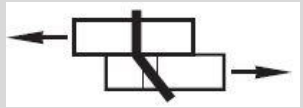

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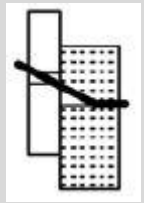

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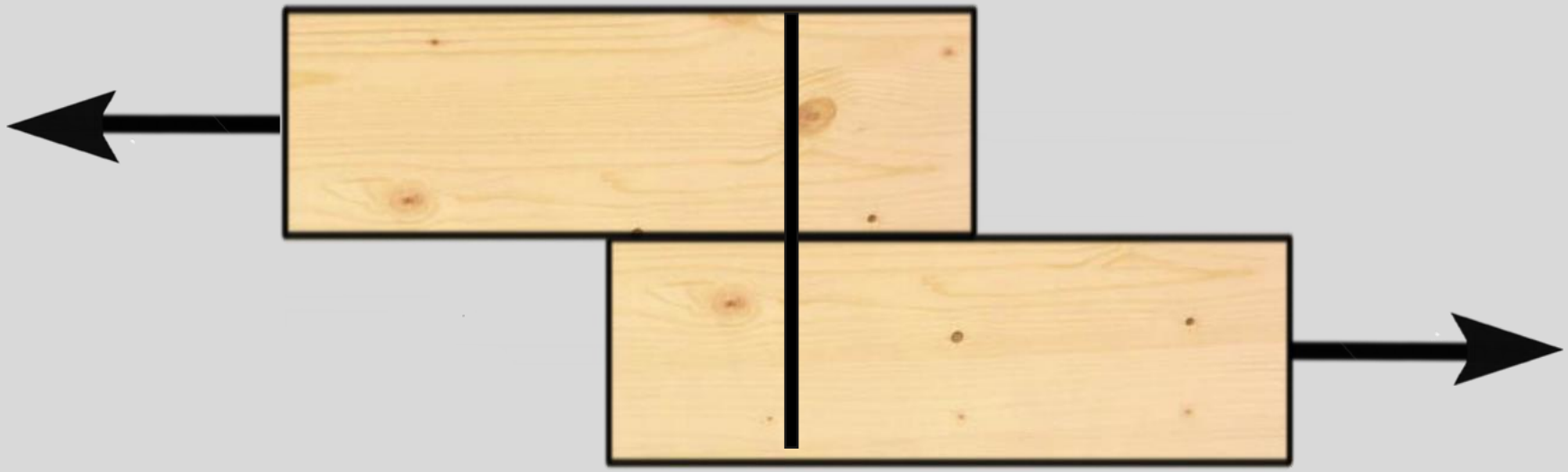

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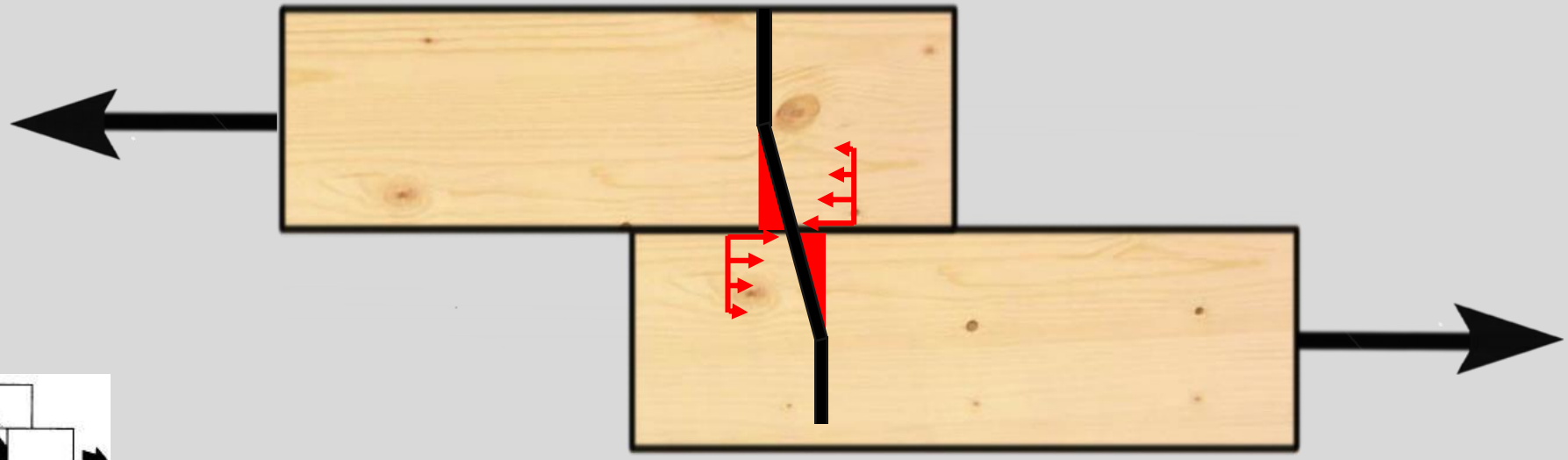
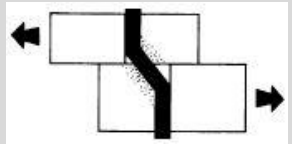


Failure Mode:

IV



(g)

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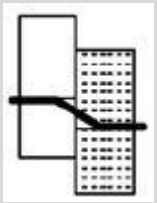

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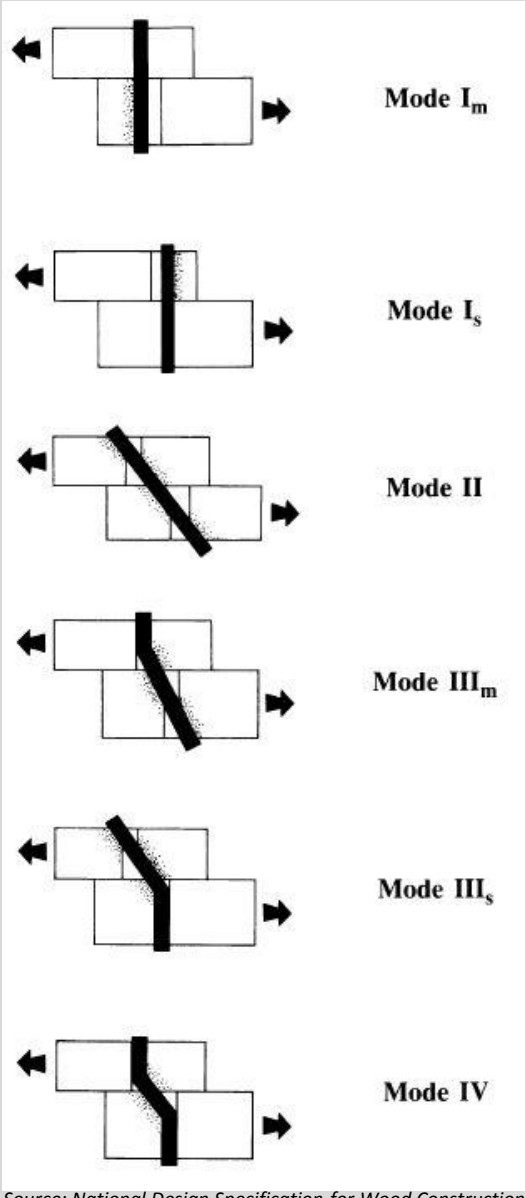


$$Z = \frac{D * l_m * F_{em}}{R_d}$$

$$Z = \frac{D * l_s * F_{es}}{R_d}$$

$$Z = \frac{k_1 * D * l_s * F_{es}}{R_d}$$

$$Z = \frac{k_2 * D * l_m * F_{em}}{(1+2*R_e) * R_d}$$

$$Z = \frac{k_3 * D * l_s * F_{em}}{(2+R_e) * R_d}$$

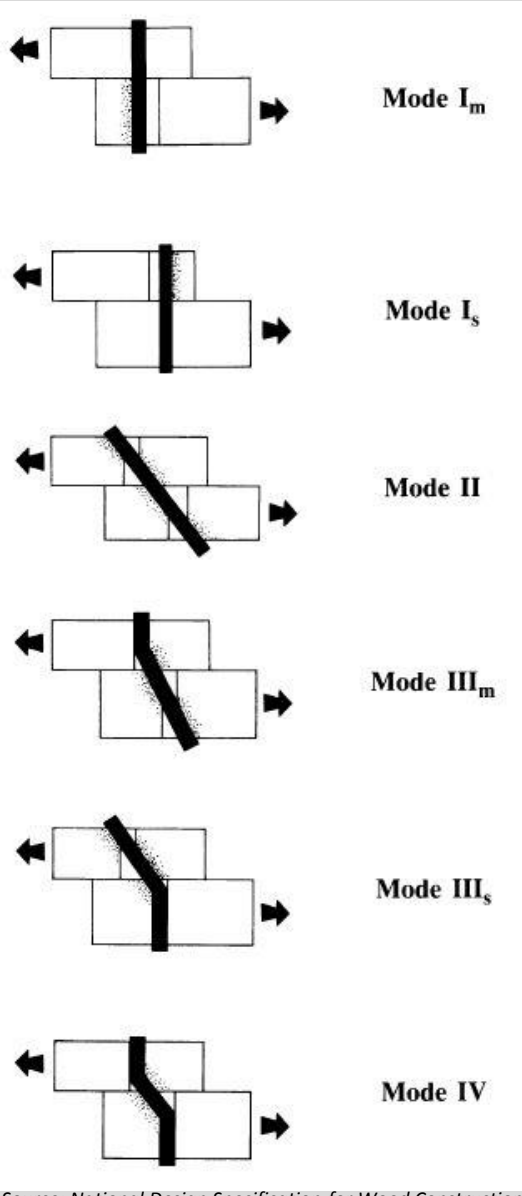
$$Z = \frac{D^2}{R_d}\sqrt{\frac{2 * F_{em} * F_{yb}}{3*(1+R_e)}}$$

Source: National Design Specification for Wood Construction - 2018

Influencing factors:

Fastener:

Basics of Lateral Connection Design



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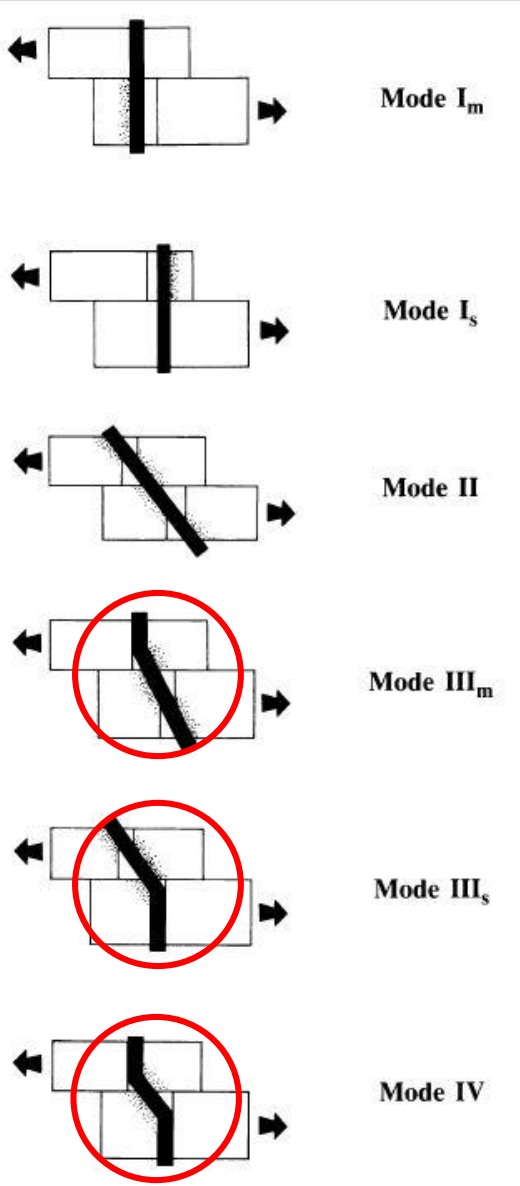
Influencing factors:

Fastener:

- Diameter [D]

Basics of Lateral Connection Design



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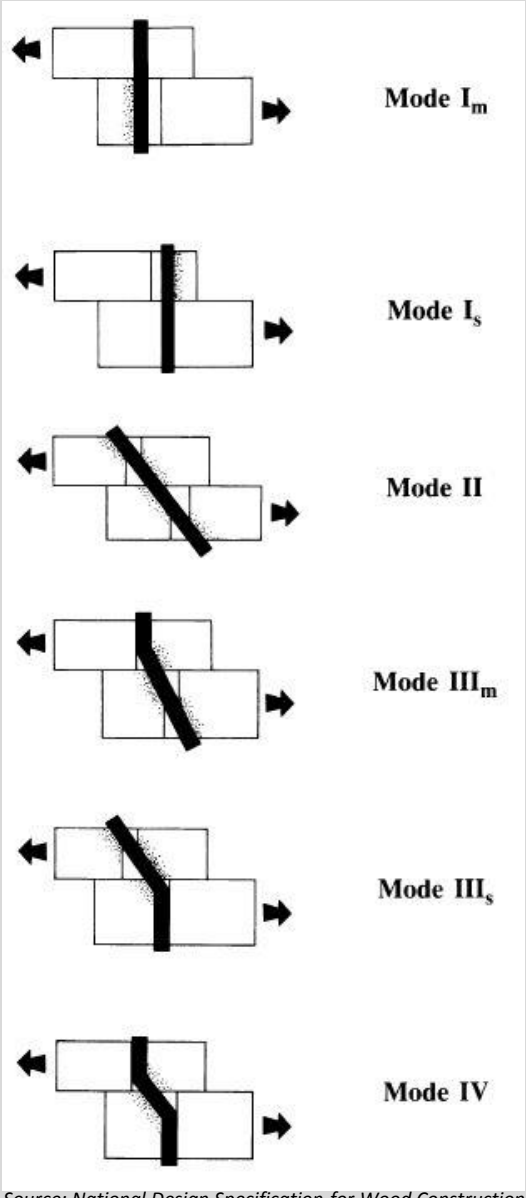
Influencing factors:

Fastener:

- Diameter [D]
- Bending Yield Strength [F_{yb}]

Source: National Design Specification for Wood Construction - 2018

Basics of Lateral Connection Design



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Influencing factors:

Fastener:

- Diameter [D]
- Bending Yield Strength [F_{yb}]
- Dowel Bearing Length [l_s ; l_m]

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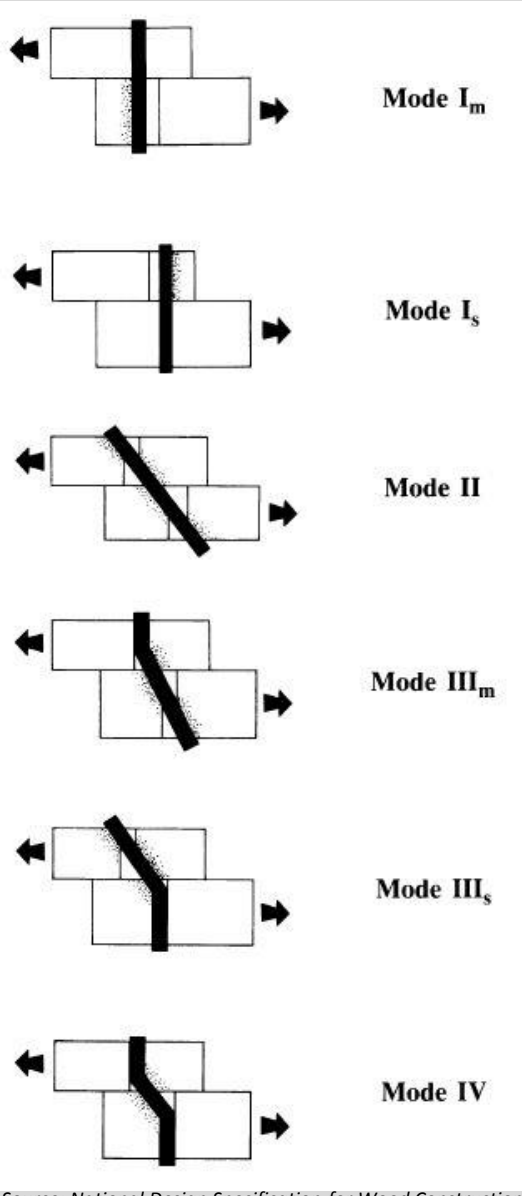

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Source: National Design Specification for Wood Construction - 2018

Influencing factors:

Fastener:

- Diameter [D]
- Bending Yield Strength [F_{yb}]
- Dowel Bearing Length [l_s ; l_m]

Wood:

- Grain direction [Θ]

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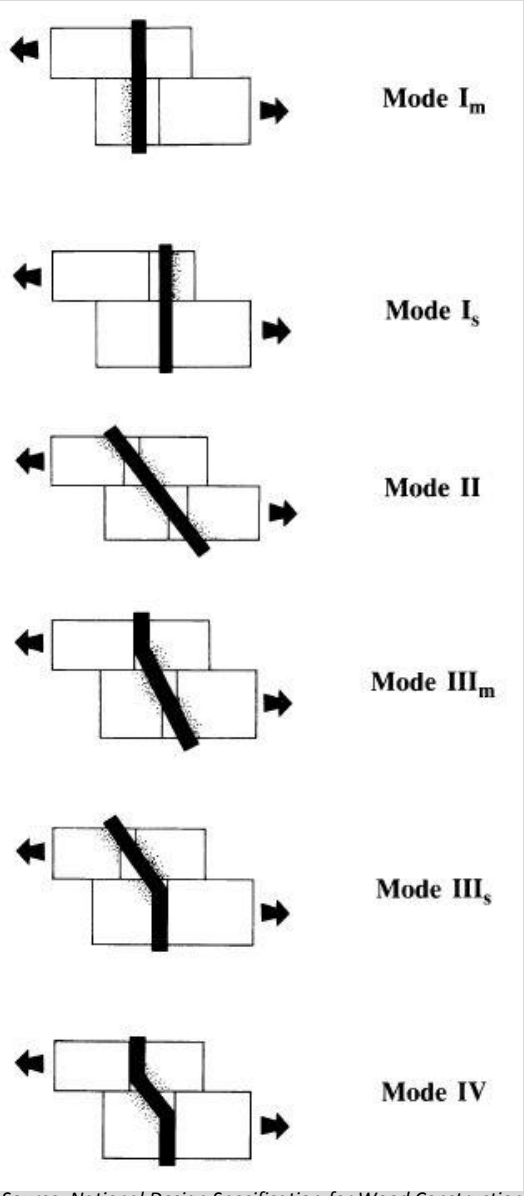

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Influencing factors:

Fastener:

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- Dowel Bearing Length [l_s ; l_m]

Wood:

- Grain direction [Θ]
- Wood Species [G]

Basics of Lateral Connection Design

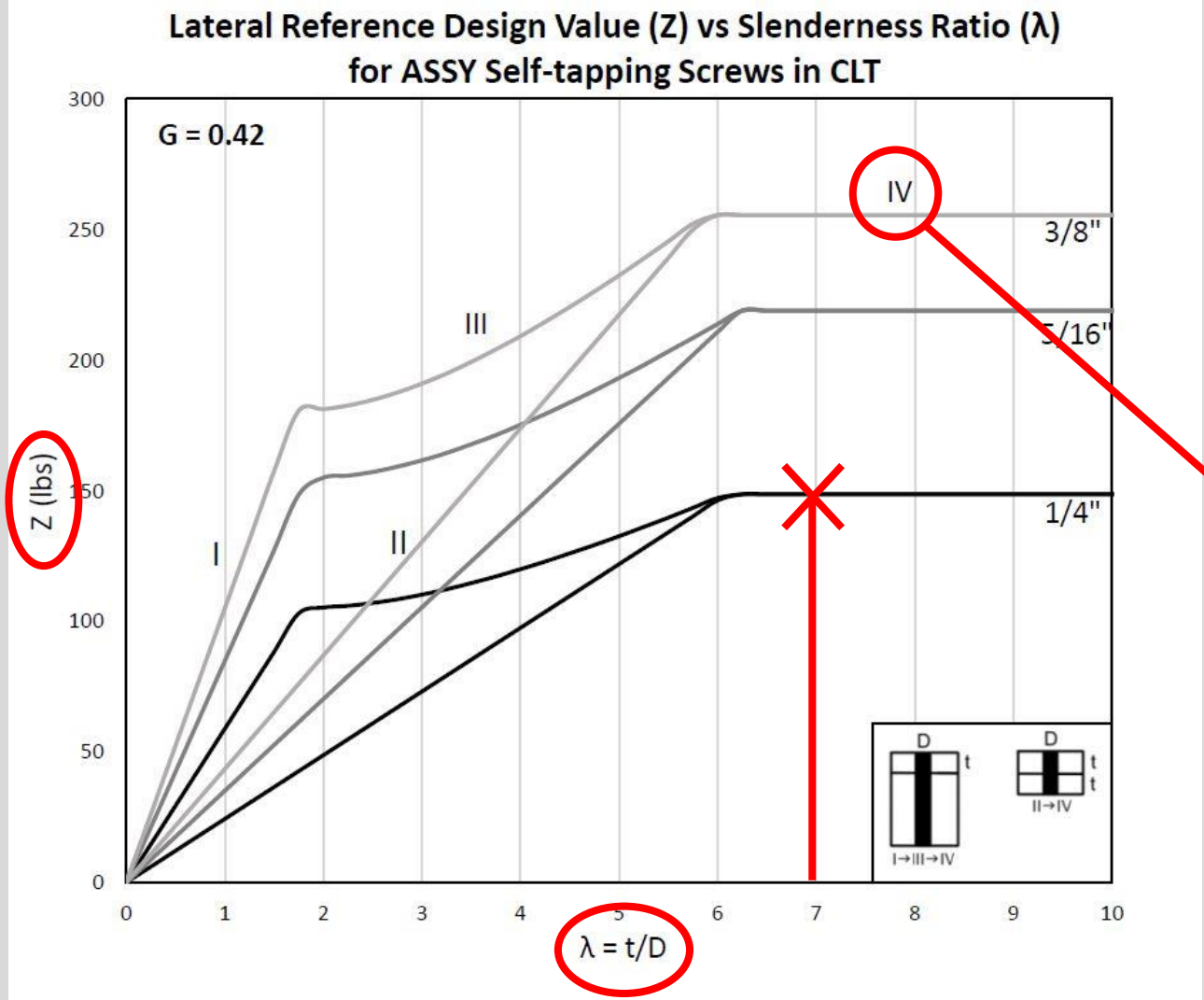


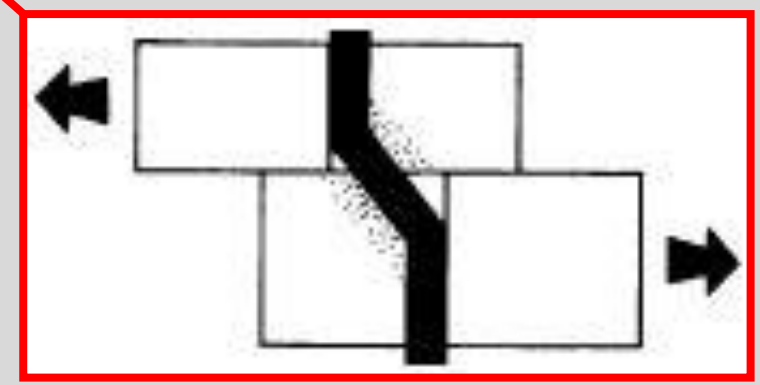
Figure (**) Fastener slenderness, lateral reference design value (Z), and failure type.

Dependency on slenderness ratio (λ):

Example:

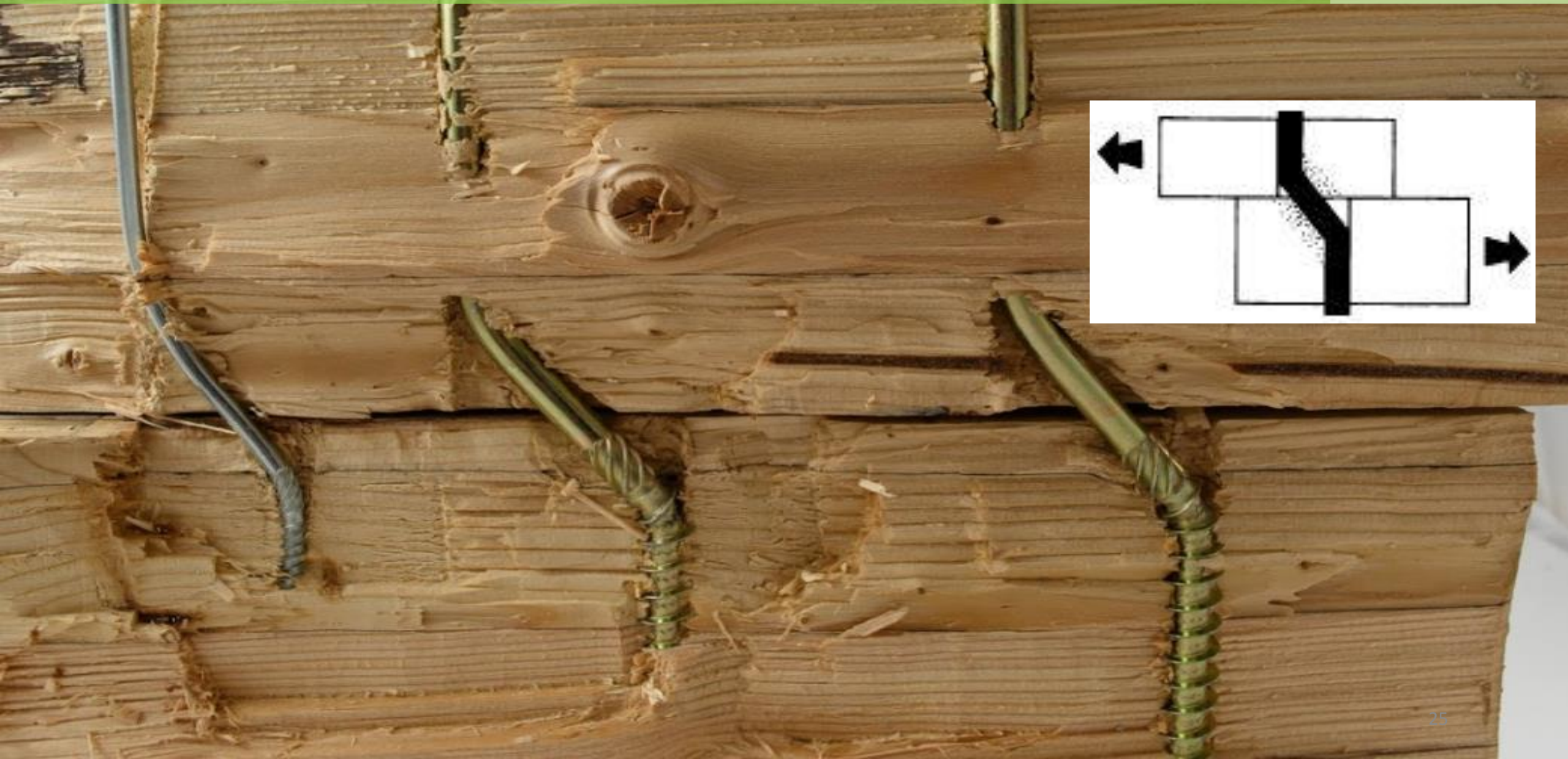
D = 1/4” l_s = 1-3/4” l_m = 1-3/4”

$$-> \lambda = 1.75 / 0.25 = 7$$



Basics of Lateral Connection Design

MyTiCon Timber Connectors



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Based on the work of K.W. Johansen

Theory of Timber Connections (1949)

3 elementary effects:

- Dowel effect of fastener (bending & wood crushing)
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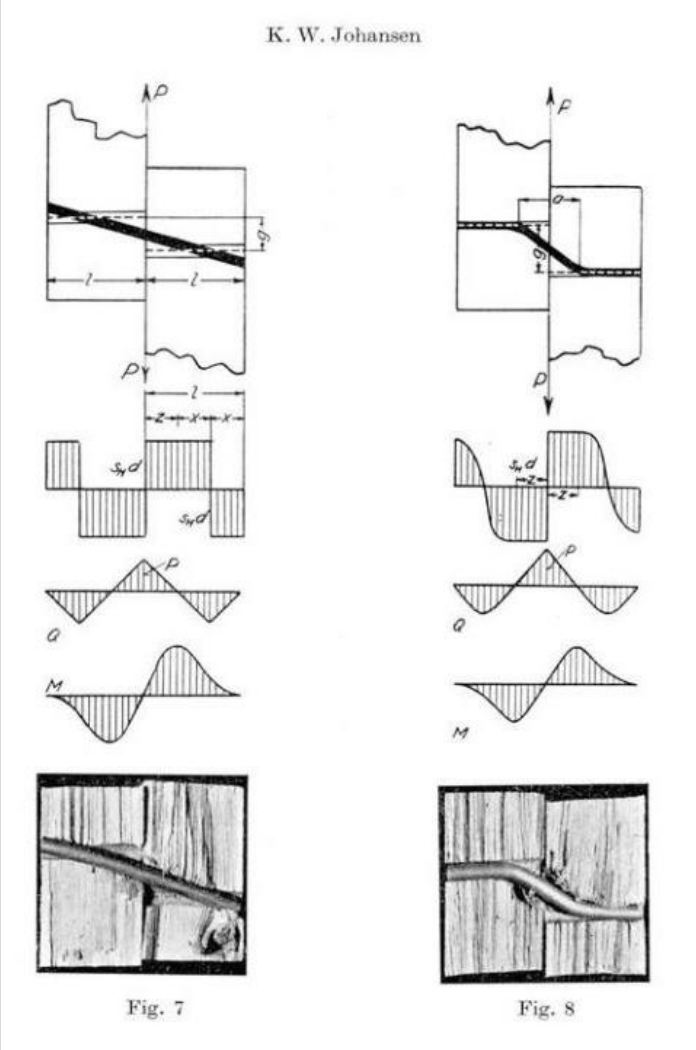

Source: Theory of timber connections; Johansen (1949)

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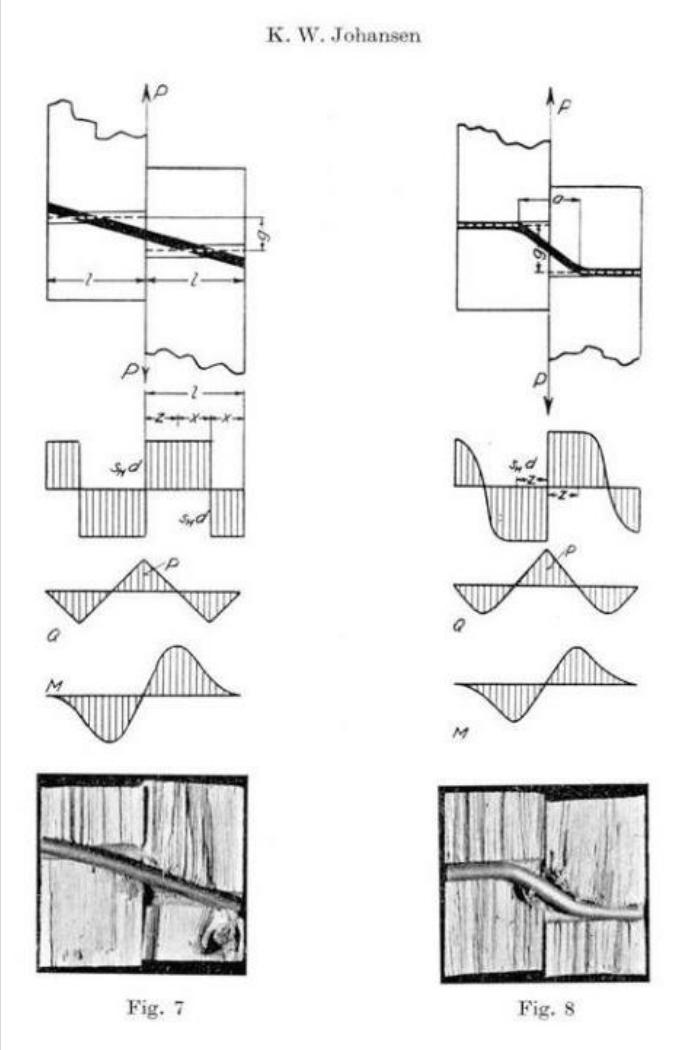

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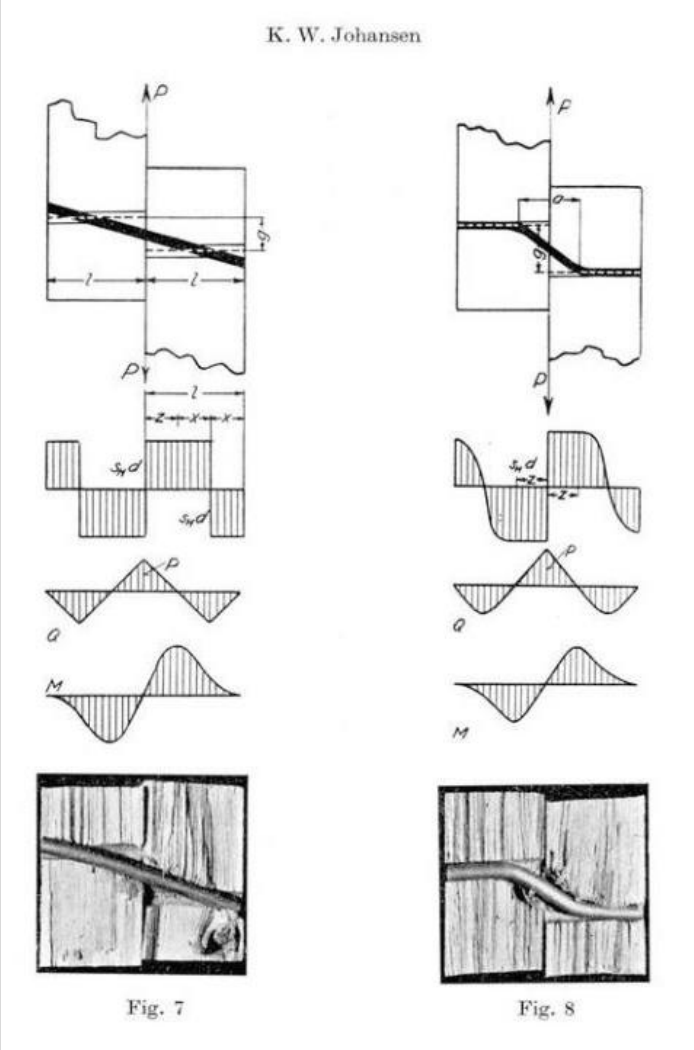

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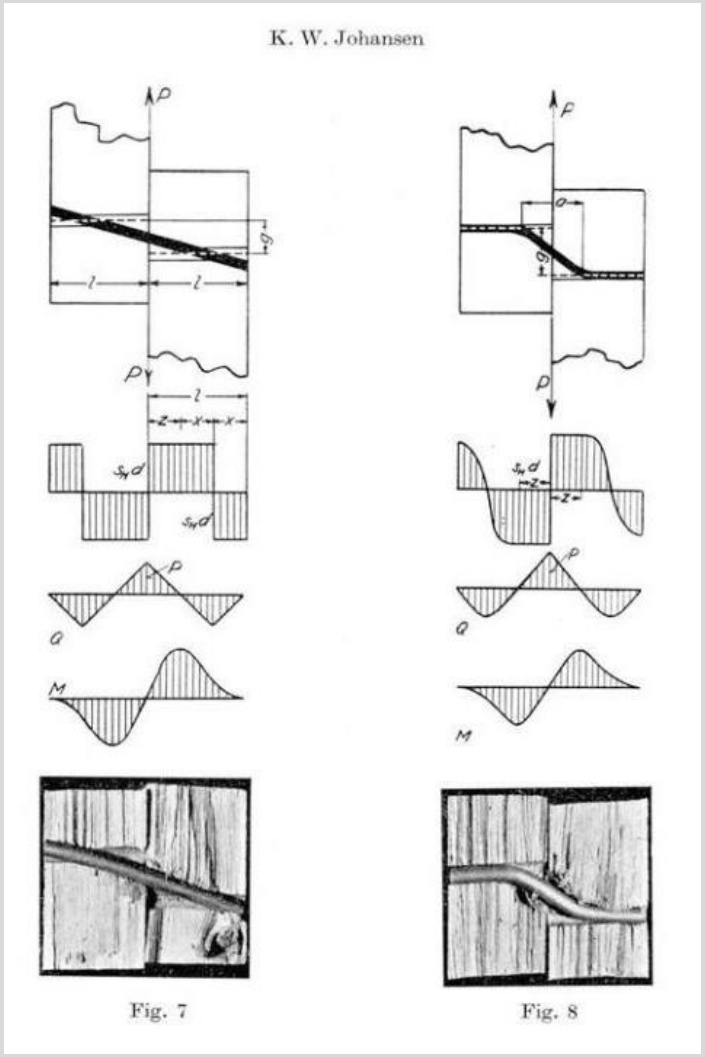

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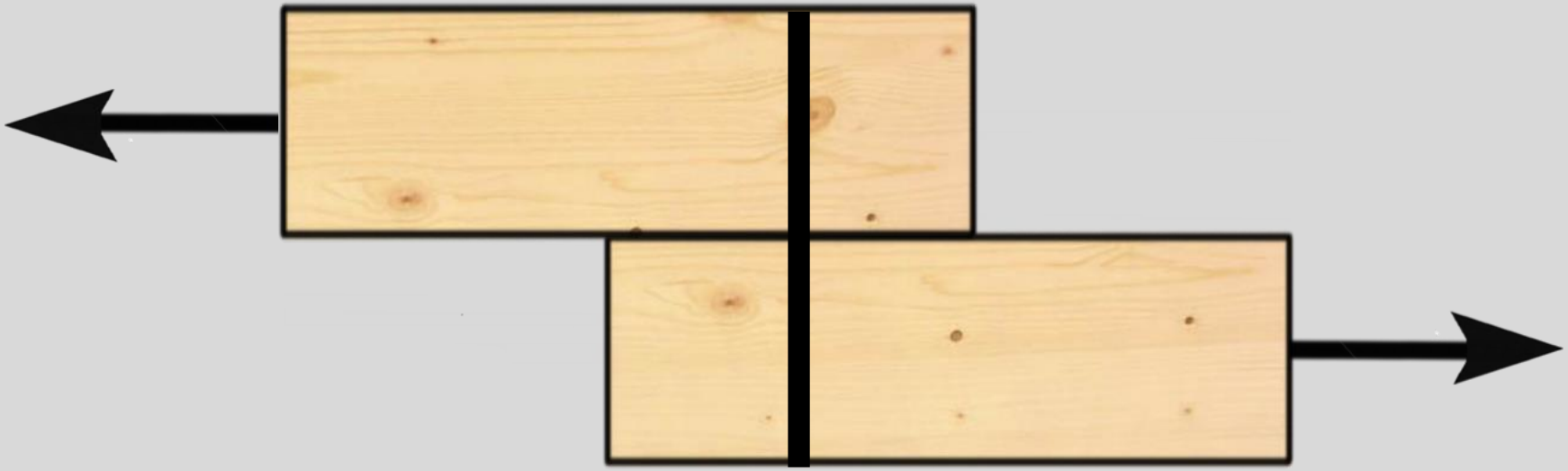
MyTiCon Timber Connectors

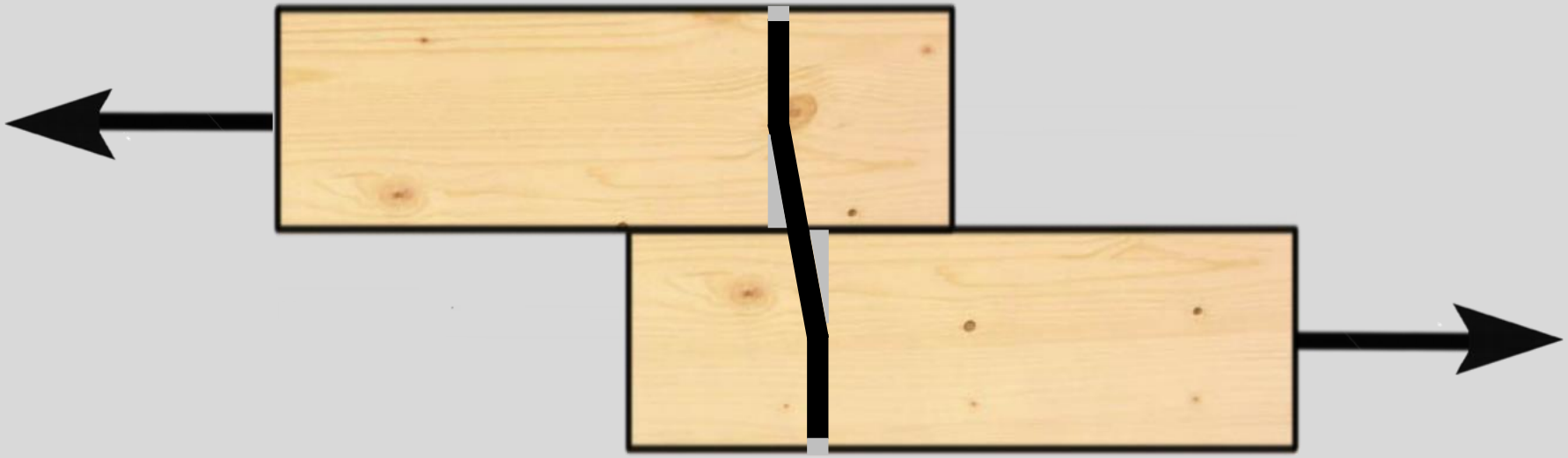
Axial effect of the Bolt



Basics of Lateral Connection Design

MyTiCon Timber Connectors

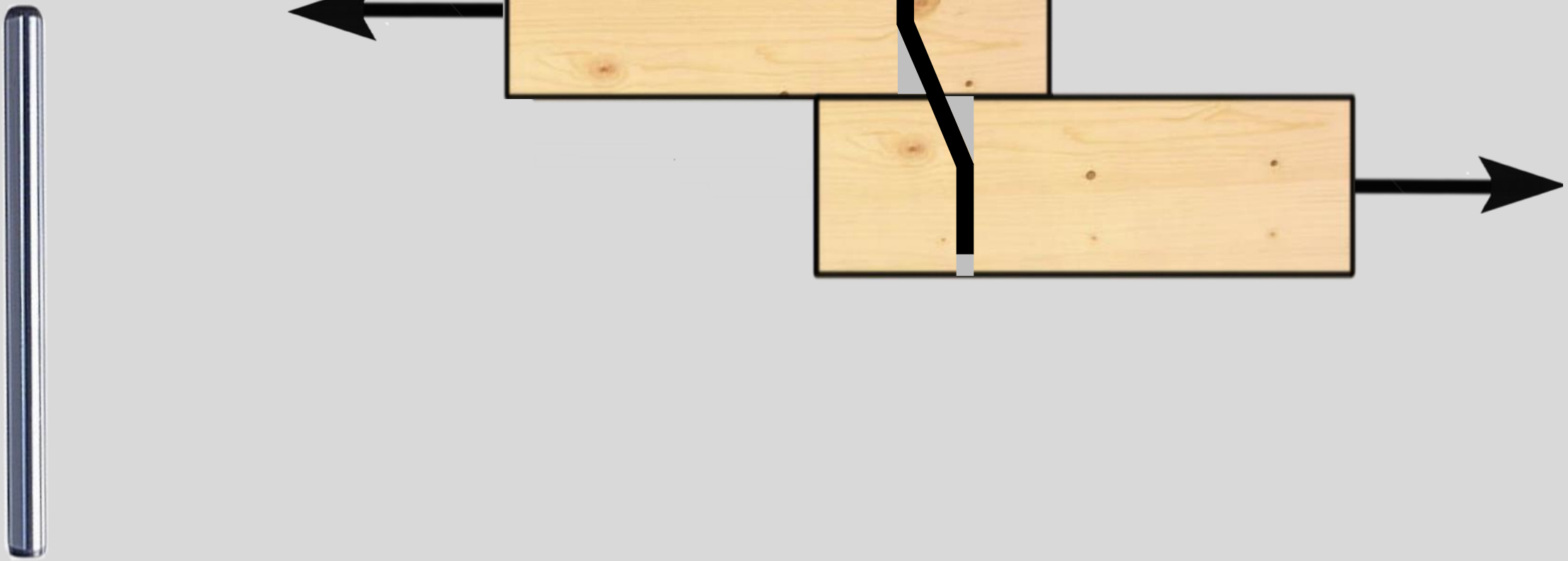
Axial effect of the Bolt



Basics of Lateral Connection Design

MyTiCon Timber Connectors

Axial effect of the Bolt



Basics of Lateral Connection Design

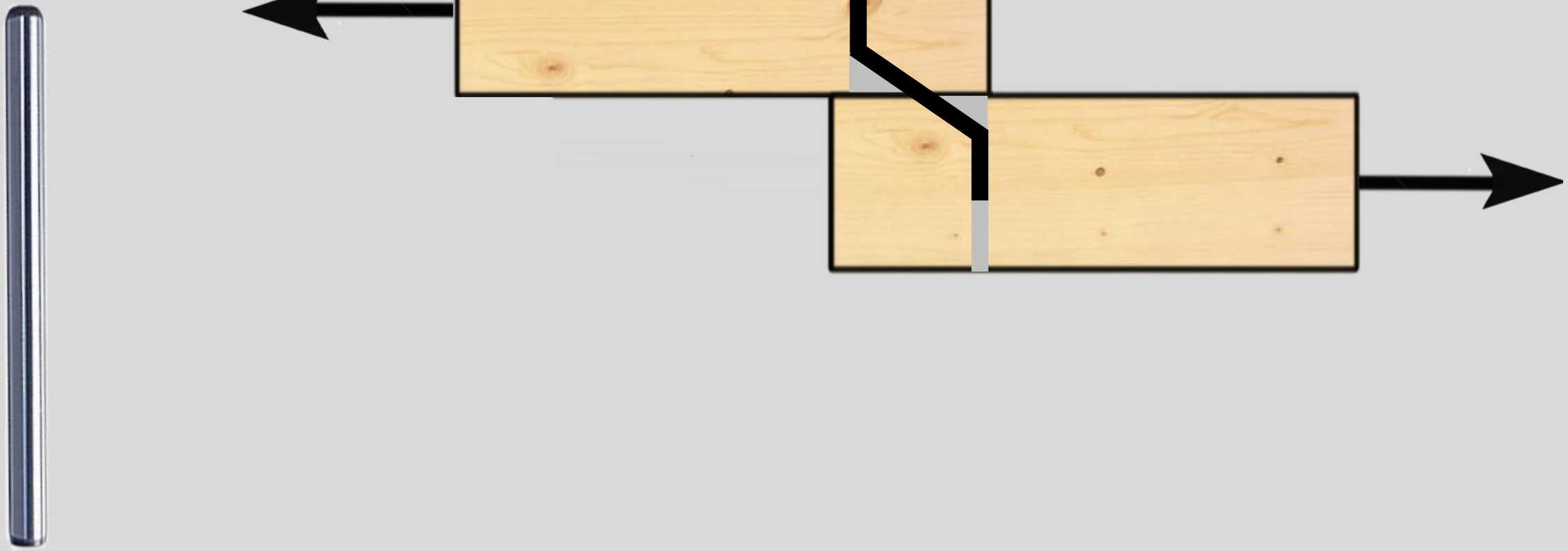
MyTiCon Timber Connectors

Axial effect of the Bolt

Basics of Lateral Connection Design

MyTiCon Timber Connectors

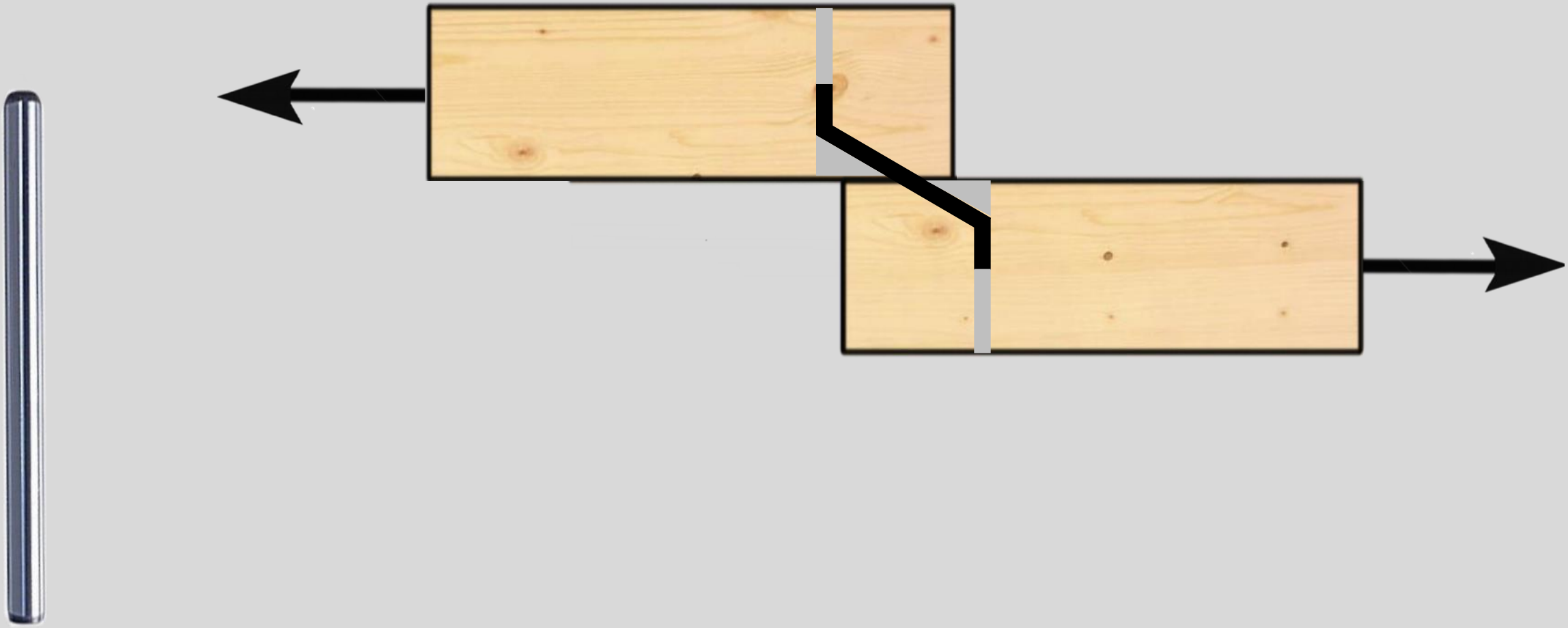
Axial effect of the Bolt



Basics of Lateral Connection Design

MyTiCon Timber Connectors

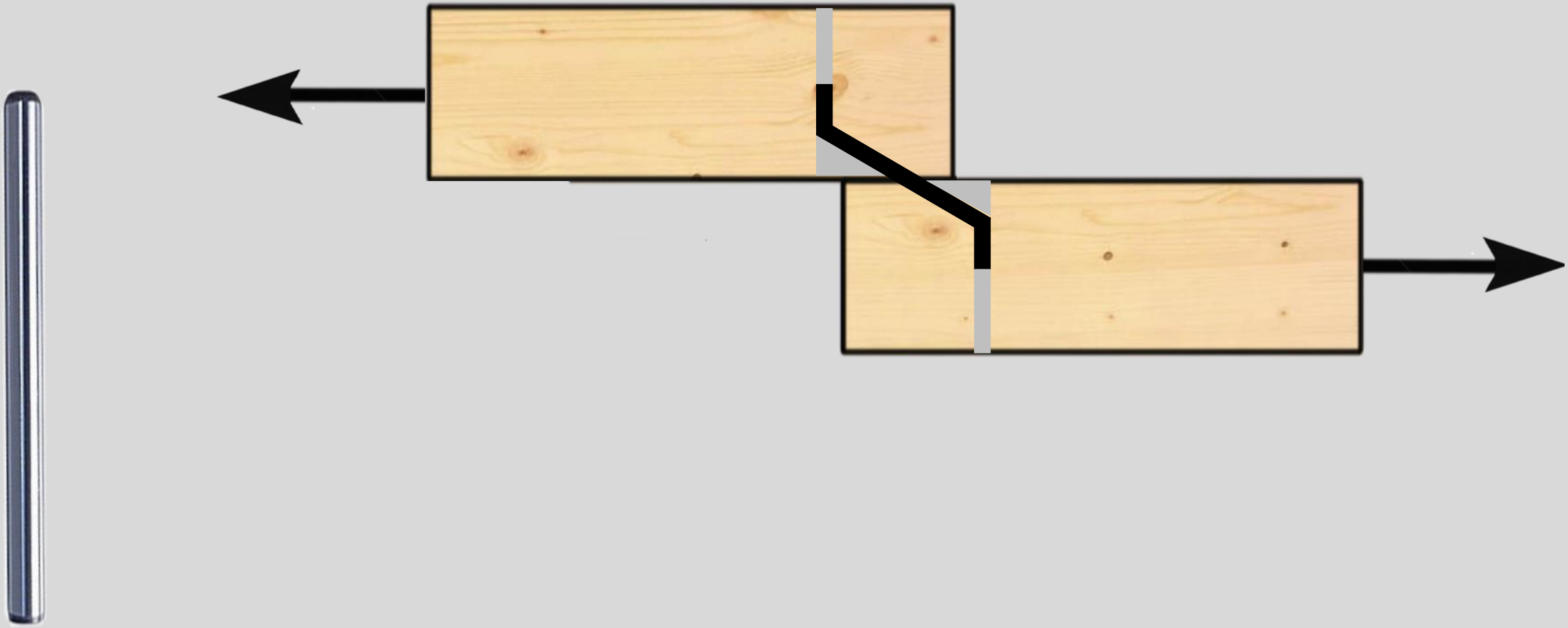
Axial effect of the Bolt



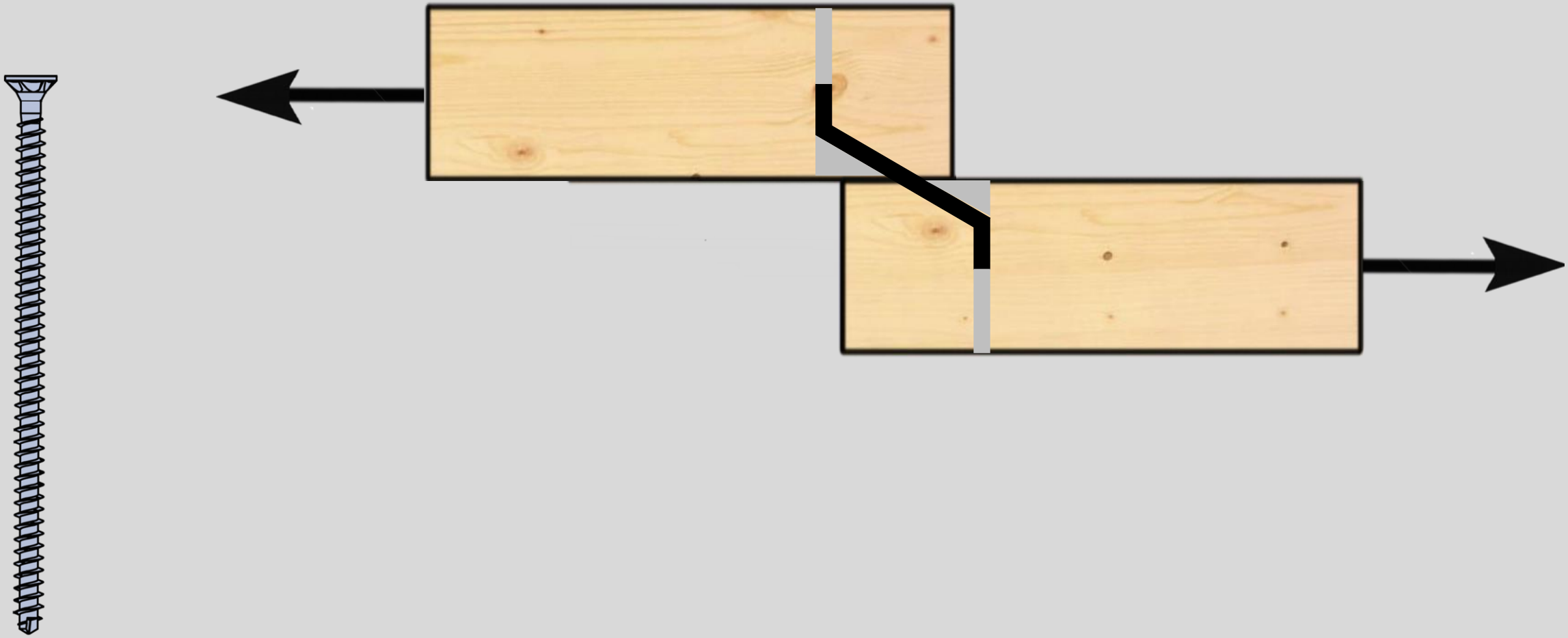
Basics of Lateral Connection Design

MyTiCon Timber Connectors

Axial effect of the Bolt



Axial effect of the Bolt



Axial effect of the Bolt

Basics of Lateral Connection Design

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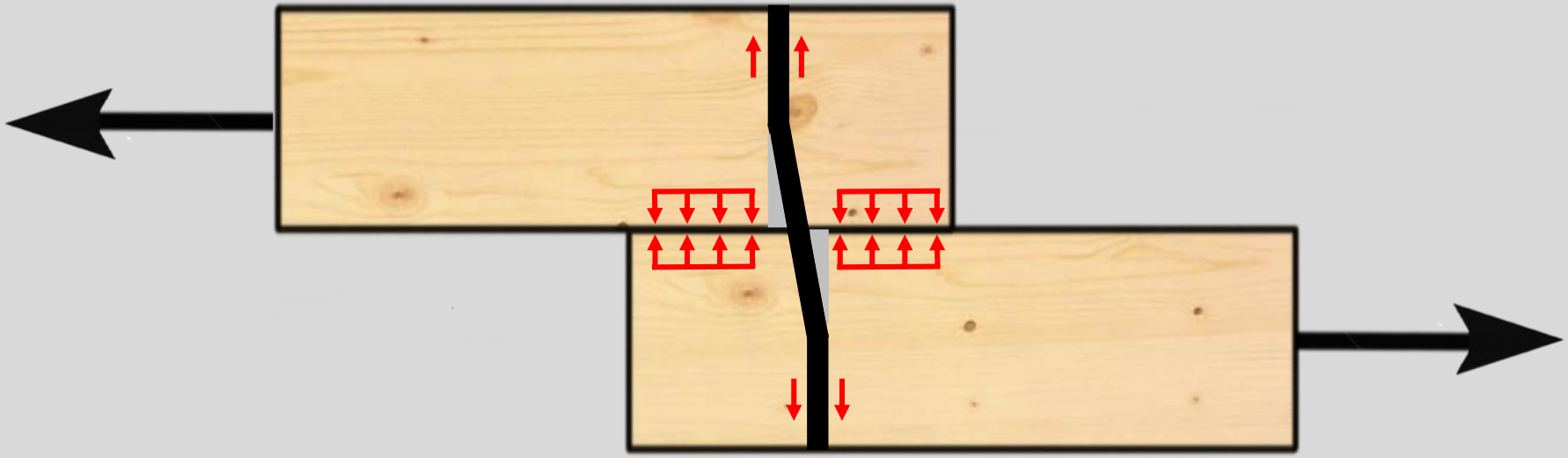
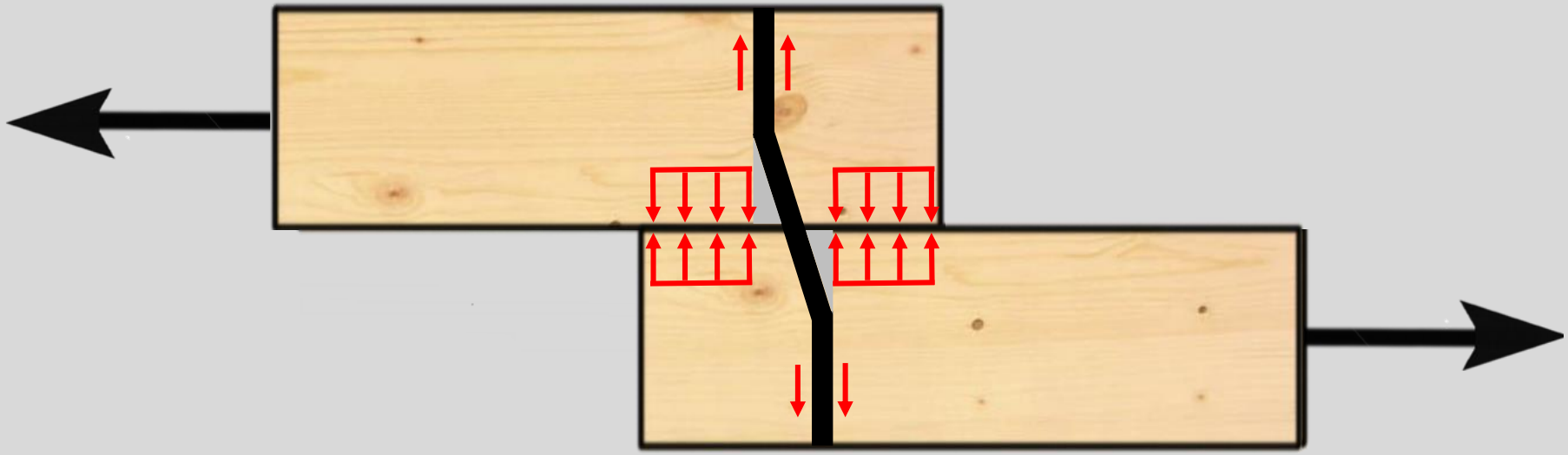
Axial effect of the Bolt

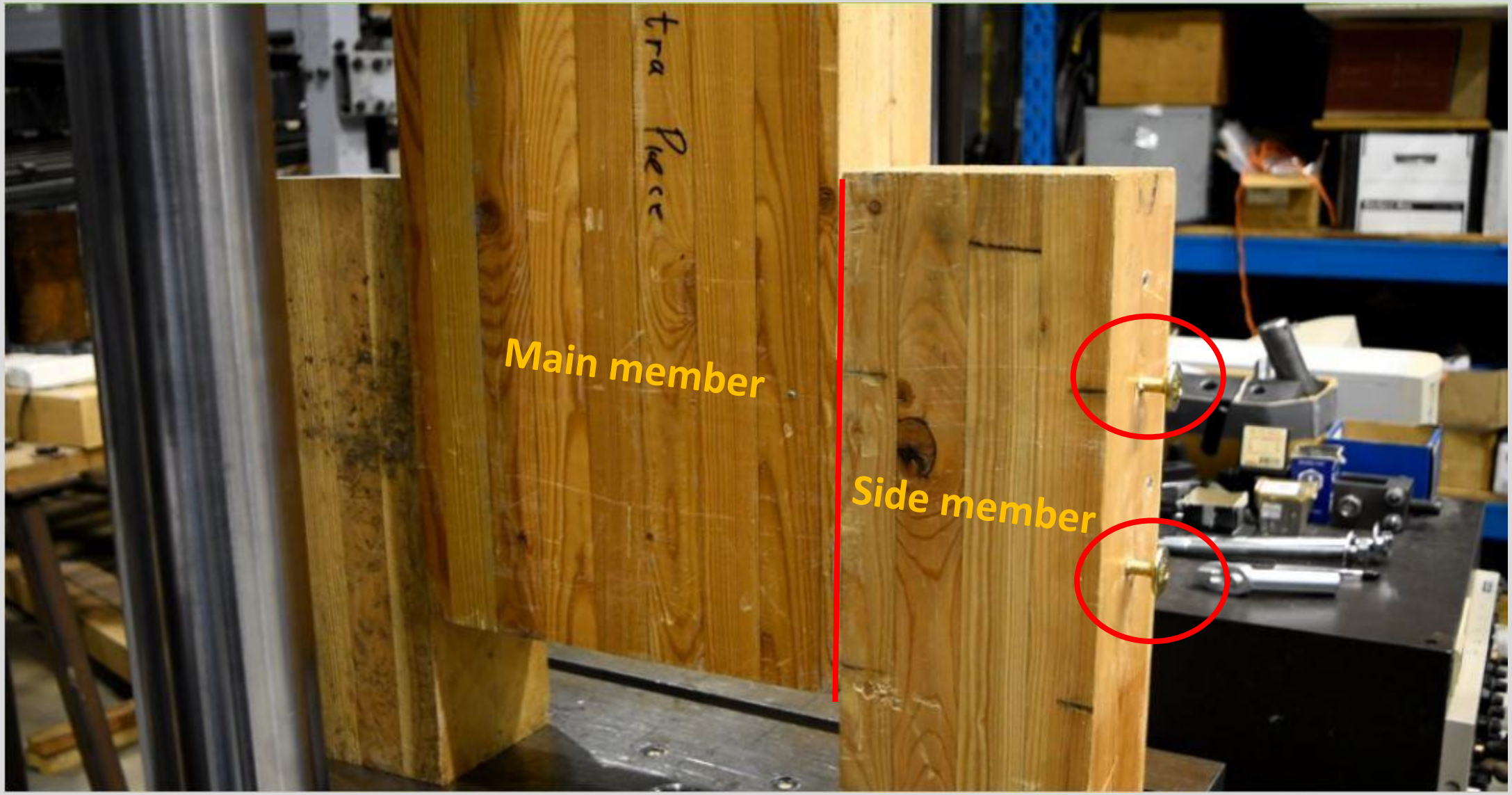


Axial effect of the Bolt



Rope-effect or String-effect

Basics of Lateral Connection Design



Rope-effect or String-effect

Does not include any axial effects

Includes axial effects only in chapter “Wood screws” and “Nails” resulting in only small capacity increase

Allows the addition of up to 25% of axial fastener capacity (can double the overall capacity for screws)

MyTiCon Timber Connectors

Rope-effect or String-effect in EUROCODE 5

8.2.2 Timber-to-timber and panel-to-timber connections

(1) The characteristic load-carrying capacity for nails, staples, bolts, dowels and screws per shear plane per fastener, should be taken as the minimum value found from the following expressions:

– For fasteners in single shear

$$F_{v,Rk} = \min \begin{cases} f_{h,1,k} t_1 d & \text{(a)} \\ f_{h,2,k} t_2 d & \text{(b)} \\ \dfrac{f_{h,1,k} t_1 d}{1+\beta}\left[\sqrt{\beta + 2\beta^2\left[1+\dfrac{t_2}{t_1}+\left(\dfrac{t_2}{t_1}\right)^2\right]+\beta^3\left(\dfrac{t_2}{t_1}\right)^2}-\beta\left(1+\dfrac{t_2}{t_1}\right)\right]+\dfrac{F_{ax,Rk}}{4} & \text{(c)} \\ 1{,}05\dfrac{f_{h,1,k} t_1 d}{2+\beta}\left[\sqrt{2\beta(1+\beta)+\dfrac{4\beta(2+\beta)M_{y,Rk}}{f_{h,1,k} d\ t_1^2}}-\beta\right]+\dfrac{F_{ax,Rk}}{4} & \text{(d)} \\ 1{,}05\dfrac{f_{h,1,k} t_2 d}{1+2\beta}\left[\sqrt{2\beta^2(1+\beta)+\dfrac{4\beta(1+2\beta)M_{y,Rk}}{f_{h,1,k} d\ t_2^2}}-\beta\right]+\dfrac{F_{ax,Rk}}{4} & \text{(e)} \\ 1{,}15\sqrt{\dfrac{2\beta}{1+\beta}}\sqrt{2M_{y,Rk} f_{h,1,k} d}+\dfrac{F_{ax,Rk}}{4} & \text{(f)} \end{cases} \quad (8.6)$$

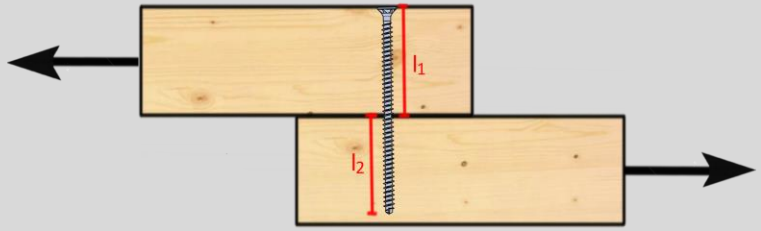
Source: Eurocode 5 Design of timber structures

Basics of Lateral Connection Design

Example:

ASSY VG CSK 1/2” x 10-1/4”

G = 0.42 (S-P-F) loaded parallel
L1 = 4-3/4”
L2 = 5”

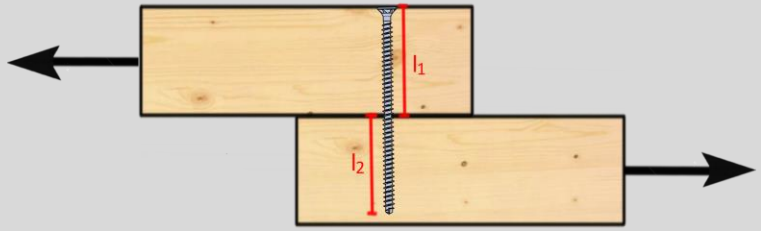


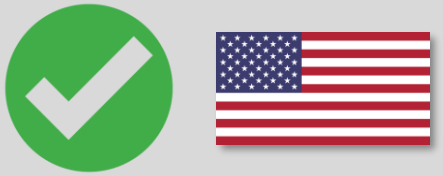
Z_{II} = 396 lbs. (NDS-2018 & ICC ESR-3178)

$N_{r,II}$ = 587 lbs. (CSA O86-2016 & CCMC 13677-R)

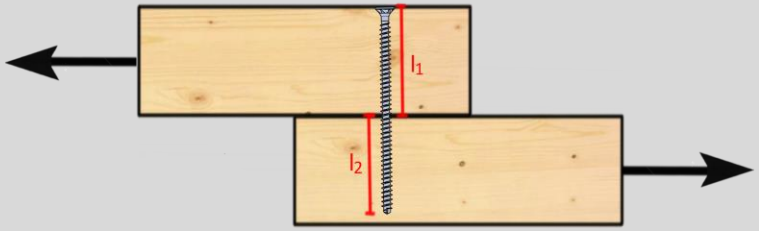
$F_{v,Rd,II}$ = 1418 lbs. (Eurocode 5 & ETA-11/0190)

Densities



	**G = 0.42**	Mean oven-dry specific gravity; unitless
	**G = 0.42**	Mean oven-dry relative density; unitless
	**ρ_k = 420 kg/m^3**	Characteristic 5%ile value of relative density at 12% MC

Load Duration



$C_D = 1.0$	Calibrated to Normal Load Duration , ~10 years
$K_D = 1.0$	Calibrated to Standard Term, >7 days
$k_{mod} = 1.0$	Calibrated to short term/instantaneous, <7 days

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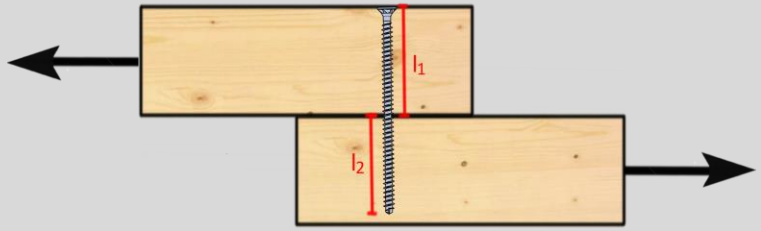
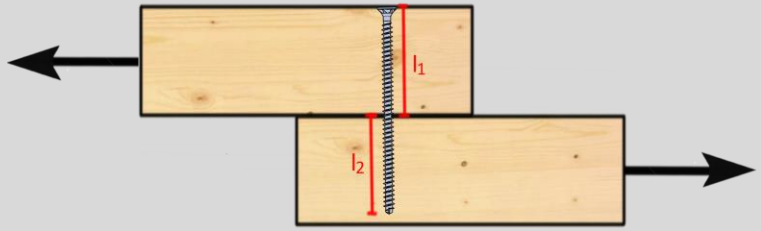
Fastener Bending Strength

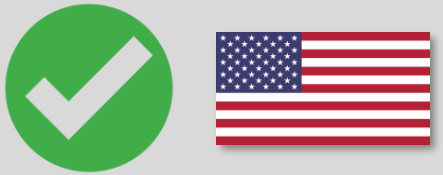


F_{yb} = 166,300 psi	Bending Yield Strength
f_y = 1,147 MPa	Bending Yield Strength
$M_{y,k}$ = 58.0 Nm	Characteristic Yield **Moment**

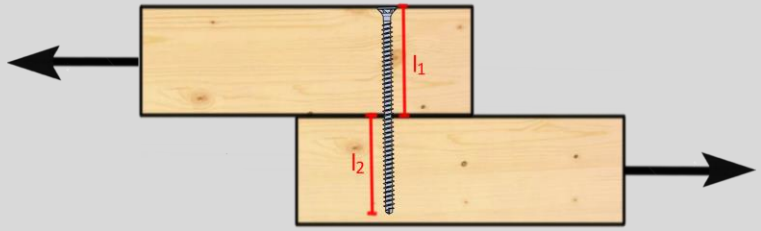
MyTiCon Timber Connectors

Diameter



	**D_r = 0.28 in.**	Root Diameter
	**D_r = 7.1 mm**	Root Diameter
	**D = 12 mm**	Outer Thread Diameter

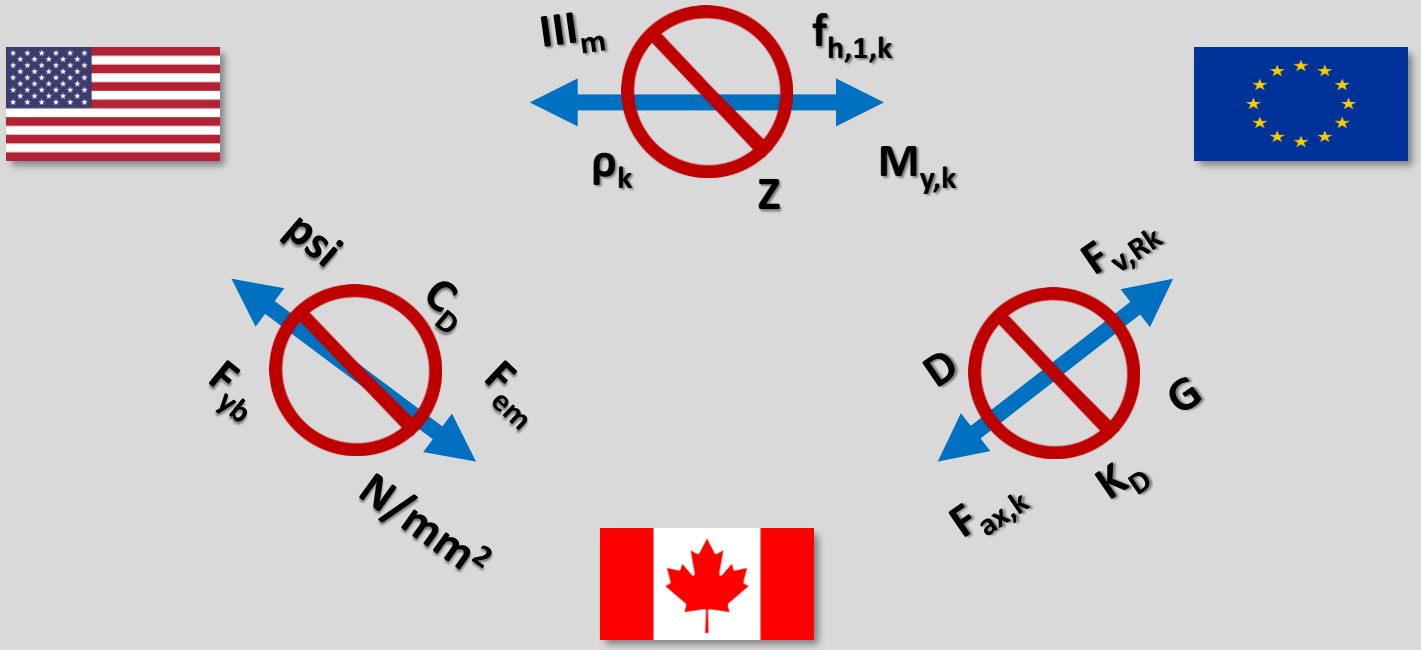
Design approach



	**ASD**	Allowable Stress Design
	**LSD**	Limit States Design
	**LSD**	Limit States Design

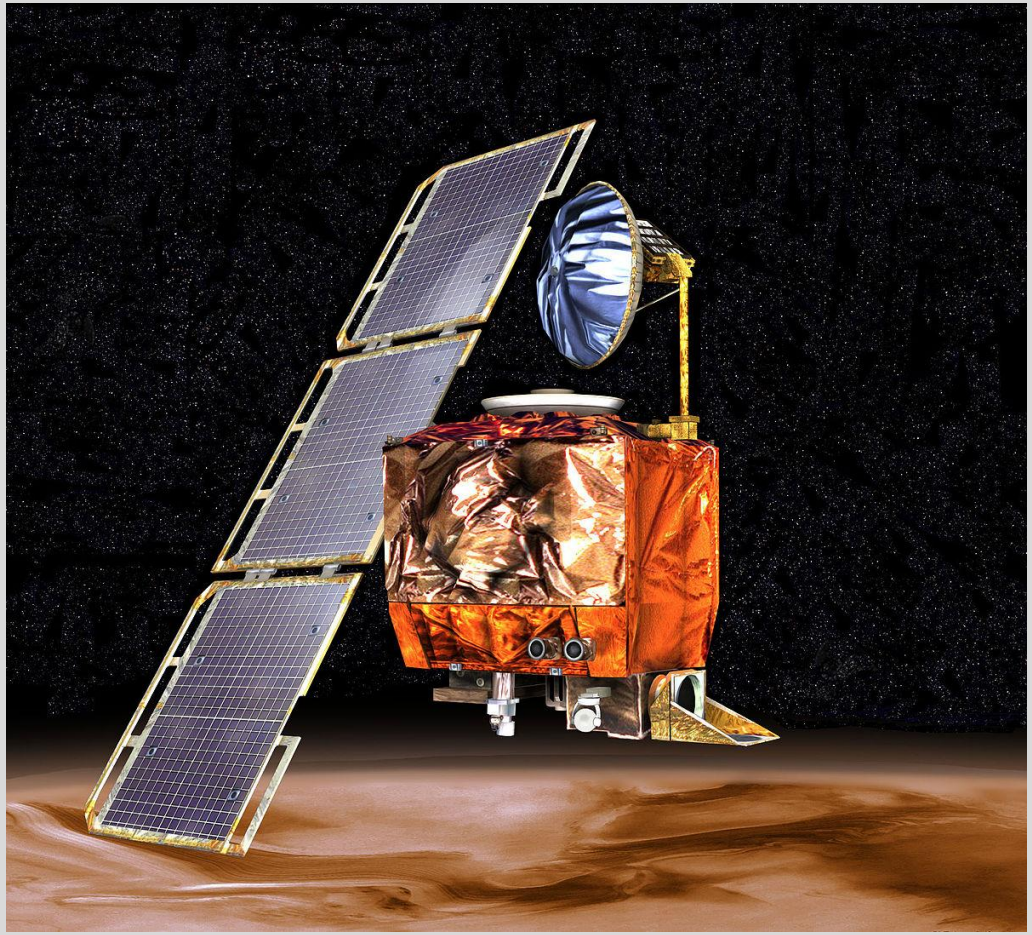
MyTiCon Timber Connectors

Conversion mistakes can lead to serious hazards!



MyTiCon Timber Connectors

Conversion mistakes can lead to serious hazards!



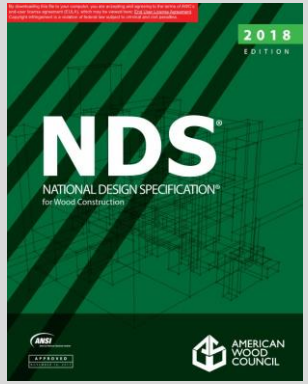
In 1999 NASA lost a $125 million Mars orbiter because of an imperial to metric conversion mistake.

Source: https://en.wikipedia.org/wiki/Mars_Climate_Orbiter

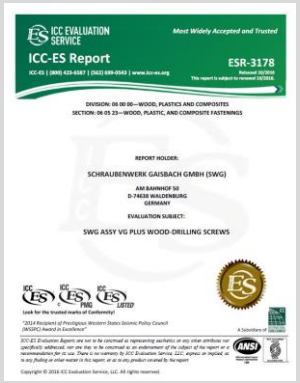
MyTiCon Timber Connectors

Conversion mistakes can lead to serious hazards!

NDS-2018



ICC ESR



CSA O86-14

CCMC

Eurocode 5

ETA

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ASSY® Reference Lateral Design Value (Z)

Table RDV.4.1, Reference Lateral Design Values (Z) for Partially Threaded Fasteners with Wood Side Member

Fastener	Side Member Thickness	Minimum Fastener Penetration into Main Member	Reference Lateral Design Values (Z) for Specific Gravities (G) of: lbs.											
			G = 0.33			G = 0.42			G = 0.49			G = 0.55		
in.	in.	in.	$Z_{\parallel}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{m\perp}$	$Z_{\perp}$	$Z_{\parallel}$	$Z_{m\perp}$	$Z_{\perp}$
1/4 x 4	2	1-3/4	131	131	131	185	185	185	213	213	213	237	237	237
1/4 x 4-3/4	2	2-1/2	142	142	142	185	185	185	213	213	213	237	237	237
1/4 x 5-1/2	2-3/4	2-1/2	148	148	148	185	185	185	213	213	213	237	237	237
5/16 x 4-3/4	2	2-7/16	164	131	131	234	187	187	280	224	224	311	249	249
5/16 x 5-1/2	2-3/4	2-7/16	185	148	148	243	194	194	280	224	224	311	249	249
5/16 x 6-1/4	2-3/4	3-3/16	194	156	156	243	194	194	280	224	224	311	249	249
3/8 x 5-1/2	2-3/4	2-3/8	310	193	154	366	248	219	396	292	273	419	314	297
3/8 x 6-1/4	2-3/4	3-1/8	325	225	179	366	265	244	396	292	273	419	314	297
3/8 x 6-1/4	3-1/2	2-3/8	323	193	178	366	248	233	396	292	273	419	314	297
3/8 x 7-1/8	3-1/2	3-1/4	325	227	202	366	265	244	396	292	273	419	314	297
3/8 x 7-1/8	4	2-3/4	325	208	193	366	265	244	396	292	273	419	314	297
3/8 x 7-7/8	4	3-1/2	325	227	205	366	265	244	396	292	273	419	314	297
3/8 x 8-5/8	5-1/2	2-3/4	325	208	193	366	265	244	396	292	273	419	314	297
3/8 x 9-1/2	5-1/2	3-5/8	325	227	205	366	265	244	396	292	273	419	314	297
1/2 x 7-1/8	3-1/2	3-1/8	456	273	212	526	351	301	569	412	377	602	443	412
1/2 x 7-7/8	3-1/2	3-7/8	467	306	236	526	374	335	569	412	379	602	443	412
1/2 x 7-7/8	4	3-3/8	467	283	237	526	368	337	569	412	379	602	443	412
1/2 x 9-1/2	5-1/2	3-1/2	467	289	265	526	374	339	569	412	379	602	443	412
1/2 x 10-1/4	5-1/2	4-1/4	467	320	285	526	374	339	569	412	379	602	443	412

Note: see notes under the table RDV.4.2.

ASSY® Factored Lateral Resistances (N_r)

Table FR.4.1, Basic Factored Lateral Strength Resistance (N'_r) for Partially Threaded Fasteners with Wood Side Member

Fastener	Side Member Thickness	Minimum Fastener Penetration into Main Member	Basic Factored Lateral Strength Resistance (N'_r) for Mean Relative Density of: N											
			G=0.35			G=0.42			G=0.49			G=0.55		
mm	mm	mm	$N'_{r,\parallel}$	$N'_{r,m\perp}$	$N'_{r,\perp}$	$N'_{r,\parallel}$	$N'_{r,m\perp}$	$N'_{r,\perp}$	$N'_{r,\parallel}$	$N'_{r,m\perp}$	$N'_{r,\perp}$	$N'_{r,\parallel}$	$N'_{r,m\perp}$	$N'_{r,\perp}$
6 x 100	38	56	731	522	344	871	664	438	975	775	511	1,063	837	574
6 x 120	51	63	829	648	418	935	731	532	1,010	790	613	1,070	837	667
6 x 140	70	64	829	648	491	935	731	609	1,010	790	670	1,070	837	710
8 x 100	38	54	995	668	438	1,267	850	557	1,478	992	650	1,630	1,114	730
8 x 140	51	81	1,284	937	628	1,528	1,193	800	1,711	1,392	933	1,864	1,477	1,031
8 x 160	64	88	1,424	1,111	724	1,651	1,291	921	1,784	1,394	1,044	1,890	1,477	1,134
10 x 140	51	79	1,720	1,135	757	2,075	1,444	963	2,316	1,685	1,124	2,517	1,891	1,261
10 x 180	64	106	1,925	1,464	990	2,294	1,863	1,259	2,571	2,054	1,425	2,784	2,177	1,544
10 x 200	89	101	2,157	1,686	1,106	2,433	1,902	1,408	2,628	2,054	1,641	2,784	2,177	1,787
10 x 220	102	108	2,157	1,686	1,222	2,433	1,902	1,556	2,628	2,054	1,743	2,784	2,177	1,847
10 x 240	140	90	2,157	1,686	1,239	2,433	1,902	1,474	2,628	2,054	1,650	2,784	2,177	1,797
10 x 260	140	110	2,157	1,686	1,356	2,433	1,902	1,614	2,628	2,054	1,743	2,784	2,177	1,847
12 x 200	89	99	2,802	1,976	1,233	3,420	2,515	1,569	3,741	2,925	1,831	3,964	3,098	2,055
12 x 220	102	106	3,055	2,215	1,364	3,464	2,708	1,736	3,741	2,925	2,025	3,964	3,098	2,273
12 x 240	140	108	3,070	2,400	1,626	3,464	2,708	2,050	3,741	2,925	2,292	3,964	3,098	2,495

Note: see notes under the table FR.4.2.

Basics of Lateral Connection Design

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Thank you!

Any Questions?

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You can contact us at:
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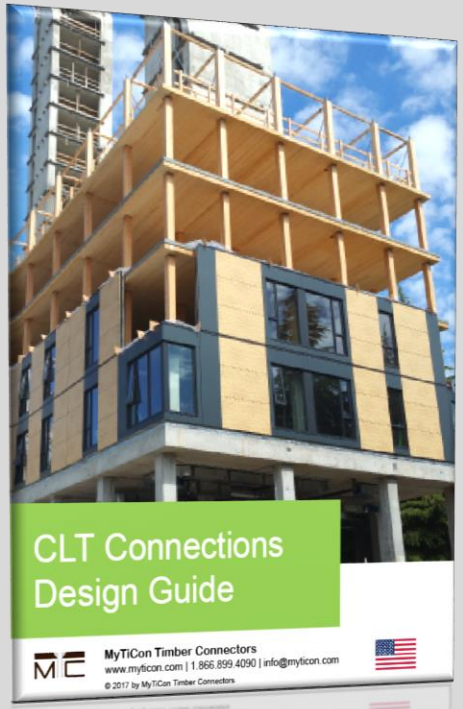
CLT Connections Design Guide



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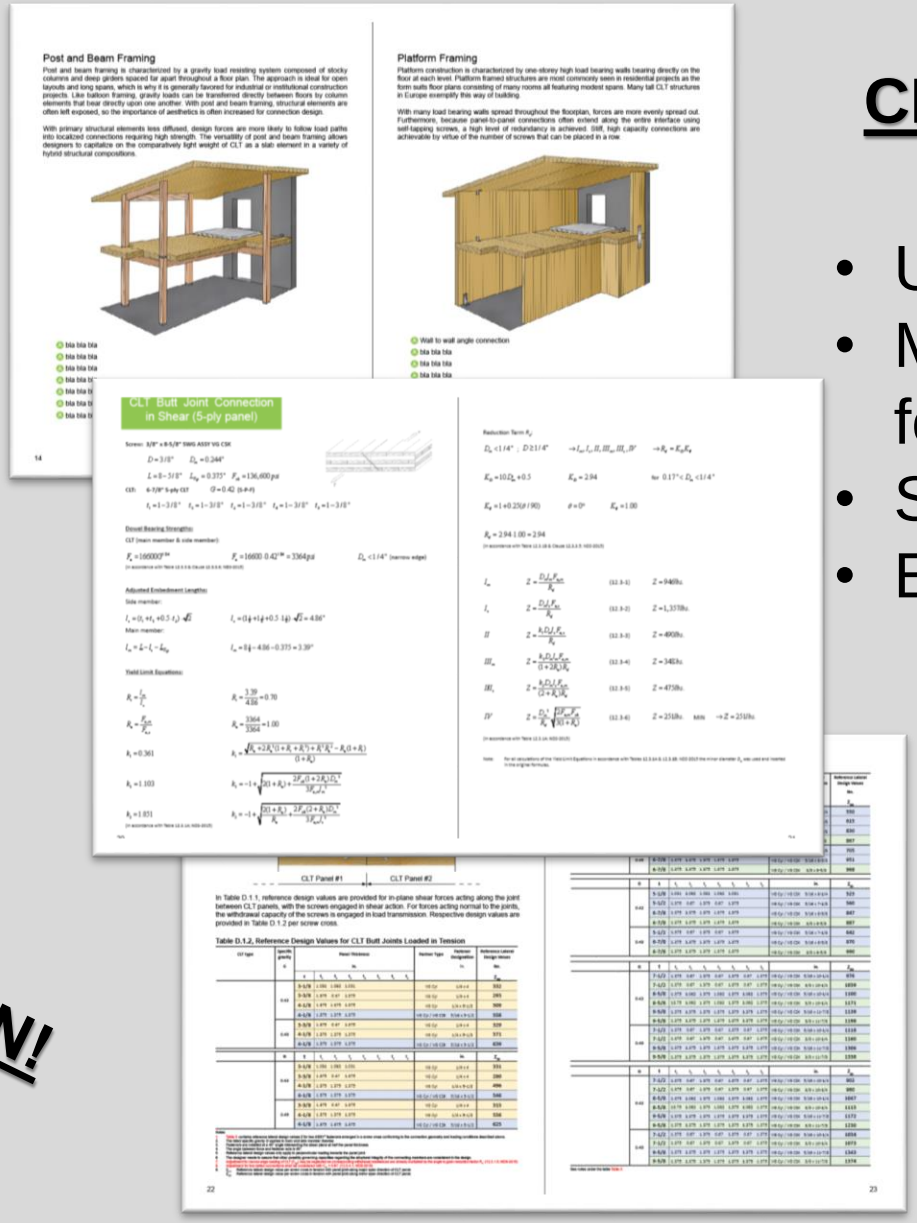

- US and CAN Editions
- Most used CLT details in table format
- Step-by-step calculations
- Everything about connecting CLT

INTERNATIONAL

MassTimber CONFERENCE

March 20-22, 2018

Thank you!

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You can contact us at:

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