Webinar Session 2/4: Basic Theory and Behavior of Inclined Screws
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Basic Theory and Behavior of Inclined Screws
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Basic Theory and Behavior of Inclined Screws

QTY = 6
Z = 3,000 lbs
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QTY = 6

Z = 3,000 lbs

QTY = 1
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**Load-displacement relationship for Specimen 12-1**

- $F_{\text{max}} = 128,300 \text{ lbs} @ 0.12^\circ$
- $570.1 \text{ kN} @ 3.0 \text{ mm}$
Keith Porter

Dalhousie University
-B.Eng. in Civil Engineering

MyTiCon Timber Connectors
-Research and Development
Outline:

• Theory of inclined screws
  • Axial vs dowel effects
• Behavior of inclined screws
  • Load-displacement relationship
  • Failure modes
• Design procedure for inclined screws
  • Simplified truss model
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**Allowable Tensile Strength**

<table>
<thead>
<tr>
<th>Size</th>
<th>Allowable</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16&quot;</td>
<td>1,775 lbs</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>2,550 lbs</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>3,470 lbs</td>
</tr>
</tbody>
</table>

**Factored Tensile Strength**

<table>
<thead>
<tr>
<th>Size</th>
<th>Factored</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/16&quot;</td>
<td>3,400 lbs</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>4,300 lbs</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>5,400 lbs</td>
</tr>
</tbody>
</table>
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![Diagram showing load-displacement relationship with F_{max} markers.]
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Basic Theory and Behavior of Inclined Screws

Mestek, P., Dietsch, P. (2011)
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European Yield Model
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European Yield Model
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Simplified Truss Model
$30^\circ \leq \beta \leq 45^\circ$
$30^\circ \leq \alpha \leq 90^\circ$

(Kevarinmäki, 2002)
Simplified Truss Model

$30^\circ \leq \beta \leq 45^\circ$

$30^\circ \leq \alpha \leq 90^\circ$

(Kevarinmäki, 2002)
Simplified Truss Model

$30^\circ \leq \beta \leq 45^\circ$

$30^\circ \leq \alpha \leq 90^\circ$

(Kevarimäki, 2002)
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Simplified Truss Model
$30^\circ \leq \beta \leq 45^\circ$
$30^\circ \leq \alpha \leq 90^\circ$

(Kevarinmäki, 2002)
Simplified Truss Model

$30^\circ \leq \beta \leq 45^\circ$

$30^\circ \leq \alpha \leq 90^\circ$
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Simplified Truss Model

30° ≤ β ≤ 45°
30° ≤ α ≤ 90°

(Kevarinmäki, 2002)
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(Kevarinmäki, 2002)
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Normal Force

Axial Component

Friction

Axial Force

Lateral Resistance

(Kevarinmäki, 2002)
Lateral Resistance = \min:\[
\text{ne}_f \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta)
\]
\[
\text{ne}_f \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta)
\]
Normal Force
Axial Component
Friction
Axial Force

Friction
Lateral Resistance $= \min:\n\begin{align*}
&n_{ef} \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta) \\
&n_{ef} \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta)
\end{align*}$

(Webinar Session 2
Basic Theory and Behavior of Inclined Screws

(Kevarimäki, 2002)
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\[
Lateral \ Resistance = \min:\left\{ \begin{array}{l}
    n_{ef} \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta) \\
    n_{ef} \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta)
\end{array} \right.
\]

(Keverinmäki, 2002)
Normal Force

Axial Component

Friction

Lateral Resistance = min:

\[ n_{ef} \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta) \]

\[ n_{ef} \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta) \]
Lateral Resistance = min:

\[ n_{ef} \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta) \]

\[ n_{ef} \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta) \]
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Lateral Resistance = \( \min \left( n_{ef} \cdot (\text{Withdrawal Resistance}) \cdot (\cos \beta + \mu \cdot \sin \beta), \ n_{ef} \cdot (\text{Tensile Strength}) \cdot (\cos \beta + \mu \cdot \sin \beta) \right) \)

\[ n_{ef} = \frac{F_{\text{multiple}}}{F_{\text{single}}} = 0.9 \cdot n \]

(Kearchromäki, 2002)
(Krenn & Schickhofer, 2009)
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Basic Theory and Behavior of Inclined Screws
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Basic Theory and Behavior of Inclined Screws
Withdrawal resistance, side members
Withdrawal resistance, side members

Withdrawal resistance, main member
Withdrawal resistance, side members
Withdrawal resistance, main member
Tensile strength of the screws
Withdrawal resistance, side members

Withdrawal resistance, main member

Tensile strength of the screws
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\[ F_{\text{max}} = 28,200 \text{lbs} @ 0.09'' \quad (126\text{kN} @ 2.4\text{mm}) \]
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Basic Theory and Behavior of Inclined Screws

Diagram showing the basic theory and behavior of inclined screws.
Withdrawal resistance, side members
Withdrawal resistance, side members

Withdrawal resistance, main member
Withdrawal resistance, side members
Withdrawal resistance, main member
Tensile strength of the screws
Withdrawal resistance, side members

Withdrawal resistance, main member

Tensile strength of the screws
F_{\text{max}} = 36,300\,\text{lbs} @ 0.09” (161.4\,\text{kN} @ 2.7\,\text{mm})
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(Based on findings from Tomassi, Crosatti & Piazza, 2011)
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Basic Theory and Behavior of Inclined Screws
Simplified Truss Model

30° ≤ β ≤ 45°
30° ≤ α ≤ 90°
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Simplified Truss Model

\[ 30^\circ \leq \beta \leq 45^\circ \]

\[ 30^\circ \leq \alpha \leq 90^\circ \]
Simplified Truss Model

$30^\circ \leq \beta \leq 45^\circ$

$30^\circ \leq \alpha \leq 90^\circ$
Simplified Truss Model

$30^\circ \leq \beta \leq 45^\circ$

$30^\circ \leq \alpha \leq 90^\circ$
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(Kevarinmäki, 2002)
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Basic Theory and Behavior of Inclined Screws

Axial Force (Compression)
Axial Force (Tension)

Axial Components

(Kevarinmäki, 2002)
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Axial Components

Axial Force (Compression)

Axial Force (Tension)

β

Lateral Resistance

(Kevarinmäki, 2002)
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Axial Components

Axial Force (Tension) = \( \min \) Withdrawal Resistance

Axial Force (Tension) = \( \min \) Tensile Strength

Axial Force (Compression) = \( \min \) Withdrawal (Push-in) Resistance

Axial Force (Compression) = \( \min \) 0.8·Tensile Strength

(Kevarinmäki, 2002)
Axial Components

Axial Force (Tension) = \min\ [Withdrawal Resistance, Tensile Strength]

Axial Force (Compression) = \min\ [Withdrawal (Push-in) Resistance, 0.8 \cdot \text{Tensile Strength}]

(Keväinmäki, 2002)
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Basic Theory and Behavior of Inclined Screws

F_{\text{max}} = 60,000lbs @ 0.08” (268kN @ 2.2mm)
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30° ≤ β ≤ 45°
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\[ 30^\circ \leq \alpha \leq 90^\circ \]
Loading parallel to grain
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Shearing joints
Geometry requirements
Symmetrical/
mutually parallel
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(Krenn & Schickhofer, 2009)
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ICC-ES Report
DIVISION: 06 00 00—WOOD, PLASTICS AND COMPOSITES
SECTION: 06 05 23—WOOD, PLASTIC, AND COMPOSITE FASTENINGS

Evaluation Report CCMC 13677-R
SWG ASSY® VG Plus and SWG ASSY® 3.0 Self-Tapping Wood Screws

MASTERFORMAT: 06 05 23 14
Evaluation issued: 2013-11-20
Re-evaluated: 2017-12-22
Re-evaluation due: 2019-11-29
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Webinar Session 2.5/4
Advanced Theory and Behavior of Inclined Screws

\[ Z'_{e} = \frac{(W'_{p})Z'}{(W'_{p})\cos^{2}\theta + Z'\sin^{2}\theta} \]
Thank you.

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Call Toll Free: 1.866.899.4090
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www.myticon.com
Resources/Further Reading


