

Consequences of EC 5 for Danish best practise

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Danish Timber Information

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- Eurocodes replaces Danish Codes from 1 Jan 2009
- Most strength parameters should be declared in the CE-mark in accordance with prEN14592
- Eurocode 5 equations can be used where applicable, but Initial Type Testing (ITT) is needed for many types of fasteners
- Eurocode 5 ought to give slightly conservative parameters

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- ITT not yet carried out for relevant fastener types
- Embedment strength not a declared parameter

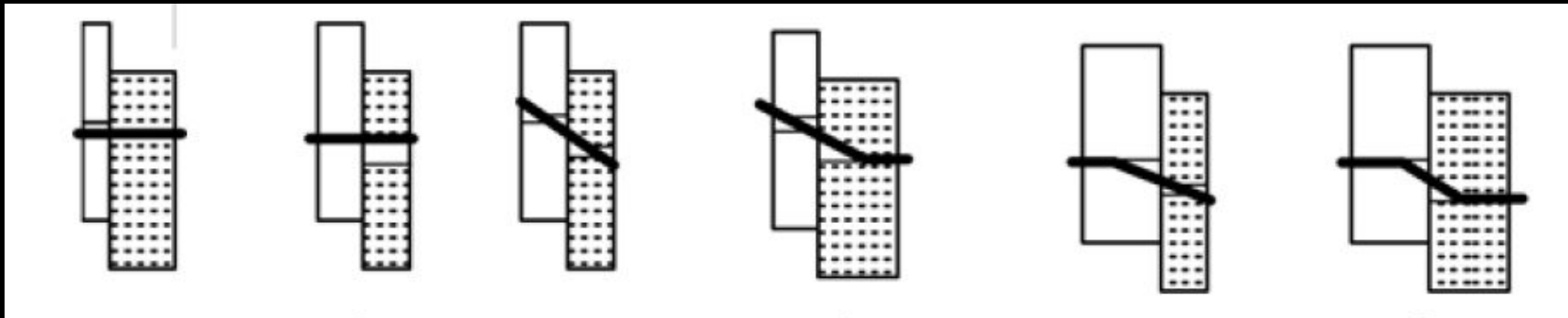
Introduction 2

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- ITT not yet carried out for relevant fastener types
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- Load capacity for fasteners generally decreases
- Some common Danish connection types can no longer be used

Strength parameters

Dowel (F_{Johansen}): combination of

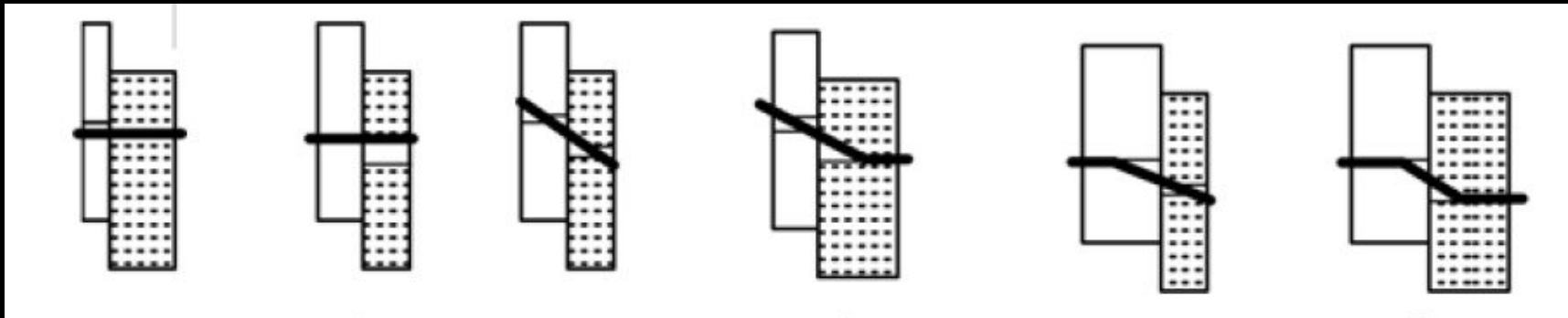
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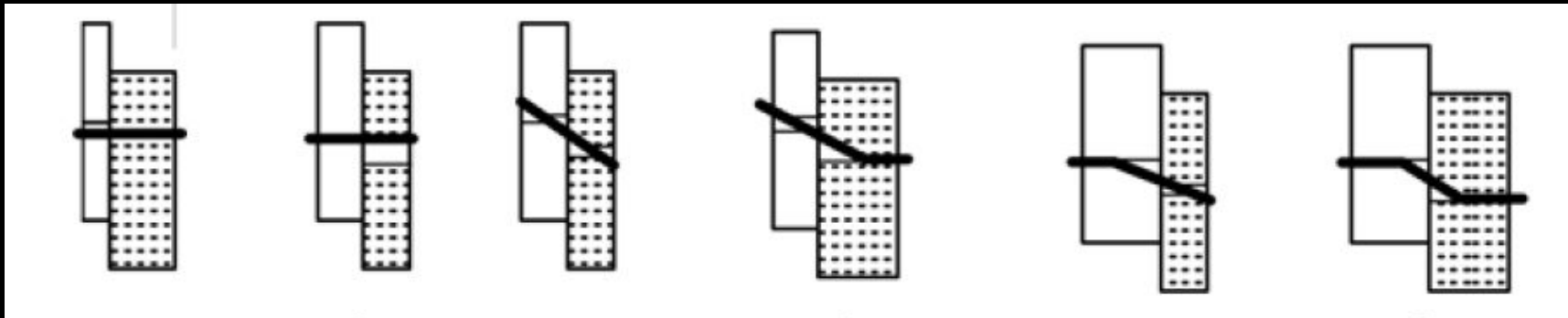
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Lateral load

- Combination of dowel and tension
- Eurocode: $F_v = F_{\text{Johansen}} + F_{ax}/4$

Density 1

- Well established that strength of fasteners depend on timber density
- Characteristic densities in EN 338 decrease rapidly with decreasing strength class:

C30	C24	C18	C14
380 kg/m ³	350 kg/m ³	320 kg/m ³	290 kg/m ³

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- Densities below 350 kg/m³ very hard to find
- Up to now 350 kg/m³ has been presupposed for all strength classes in Denmark
- C18 is most widely uses in Denmark – looses 10 % of density

Density 2

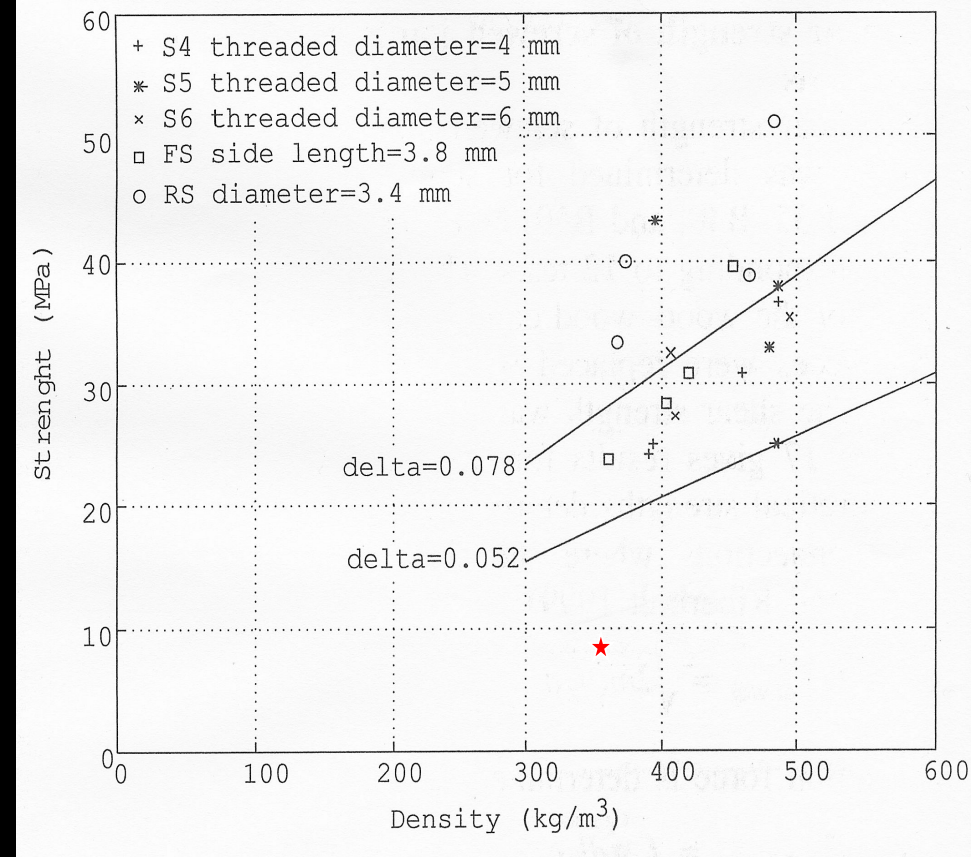
- Strength class for Nordic timber is usually governed by knot sizes – not the clear wood properties
- This might explain why the experience using 350 kg/m³ is good
- If different grow conditions causes other relations for timber grown in other places EN 338 ought to take account of regional differences

Axially loaded fasteners

- Head pull-through
- Withdrawal

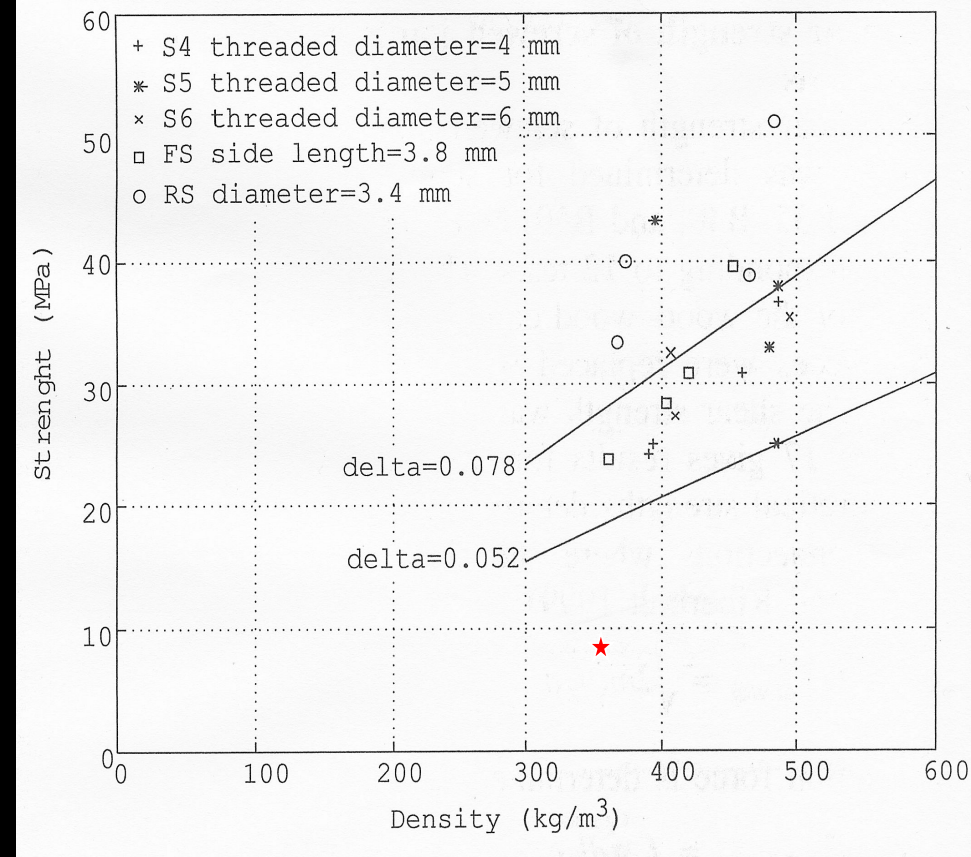
Head pull-through

- Eurocode value formally given only for smooth nails
- Very low strength given
- Should be similar for threaded nails and screws
- Nails: Depends on ρ^2 !
- Screws: Depends on $\rho^{0.8}$?
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- Correction from $\rho = 350$ to $\rho = 410$ with $\rho^{0.8}$ makes only 3% difference from linear correction !



Correction of measured strength for density

Example:

Head pull through, threaded nail, $d_{\text{head}} = 5.5 \text{ mm}$

- $F_{\text{mean}} = 1500 \text{ N}$, $\text{CoV} = 12.5\%$, $\rho = 475 \text{ kg/m}^3$
- $f_{k,475} \sim 0.75 \cdot 1500 / 5.5^2 = 36,4 \text{ MPa}$
- Approved institute corrects to $\rho = 350 \text{ kg/m}^3$ assuming linear relationship:

$$f_{k,350} = 26.8 \text{ MPa} (\sim 3 \times \text{EC5 for smooth nail})$$

- Using EC5's ρ^2 -dependency unsafe for high ρ
- Correction must be done with ρ^2 :

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- $f_{k,350} = 19.8 \text{ MPa} (\sim 2.3 \times \text{EC5 for smooth nail})$
- Preferable to use timber with smaller density for tests
 - or a range of densities including low densities

Withdrawal – smooth nails

- Strength parameters given are NOT conservative!
 - especially not for round nails
- No difference in EC5 between round and square nails
- Reduction factor $2/3$ for timber near to saturation not enough according to old Danish tests, might be $1/3$

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- High withdrawal strength for smooth nail encourage the use of smooth nails for fastening of eg. roof battens
 - which might cause wind storm damage

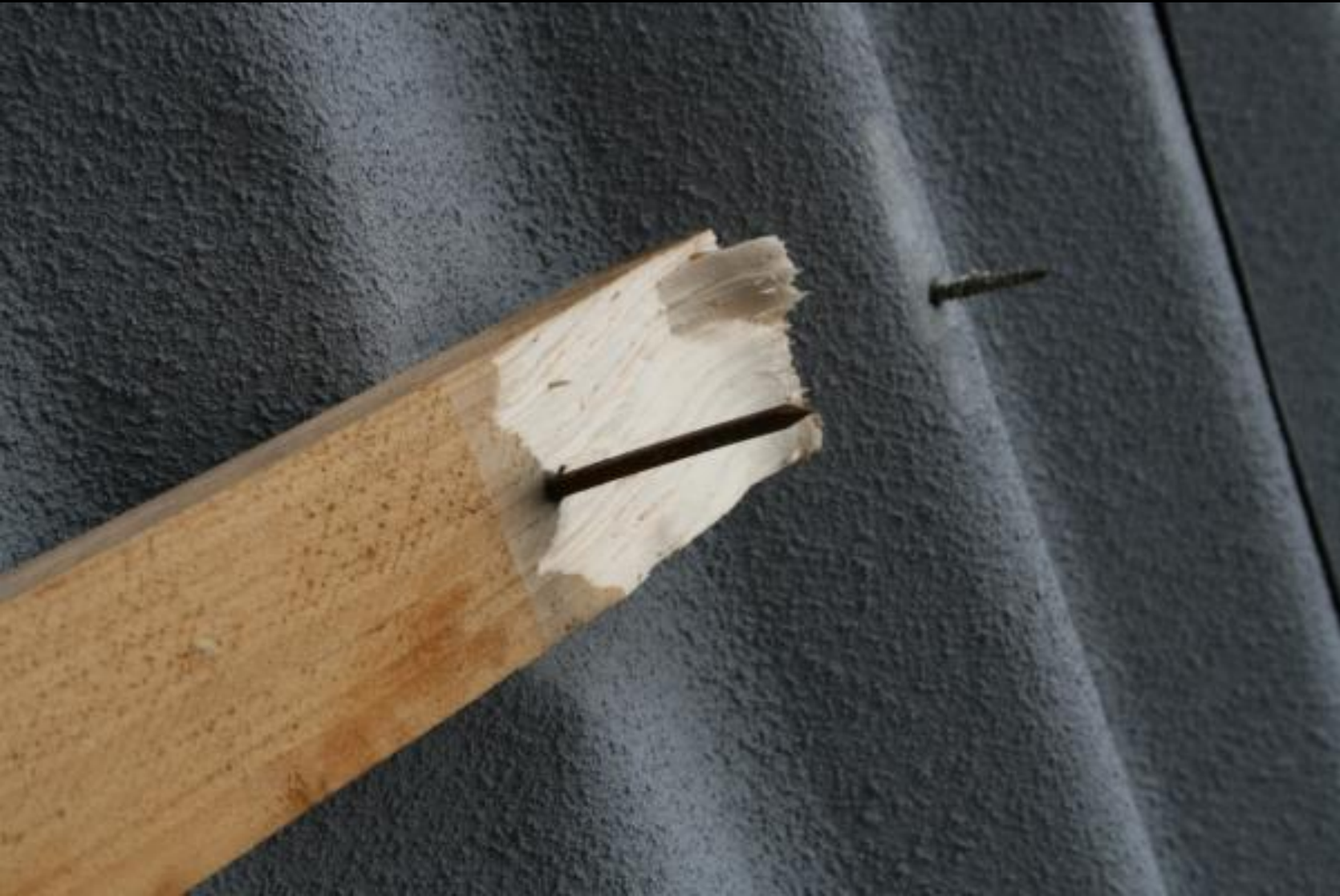
Roof of steel plates

- 300 m² blew off
- Wind speed far from characteristic
- Other part of the roof blew off 3 years ago
- No strengthening considered!



Cause

- Battens fastened with smooth nails (square and rusty)



Withdrawal – threaded nails

- Strength parameter must be declared individually
- Tests show no significant influence of changing moisture so the reduction factor $2/3$ for timber near to saturation should not be applied for threaded nails (and pull-through)

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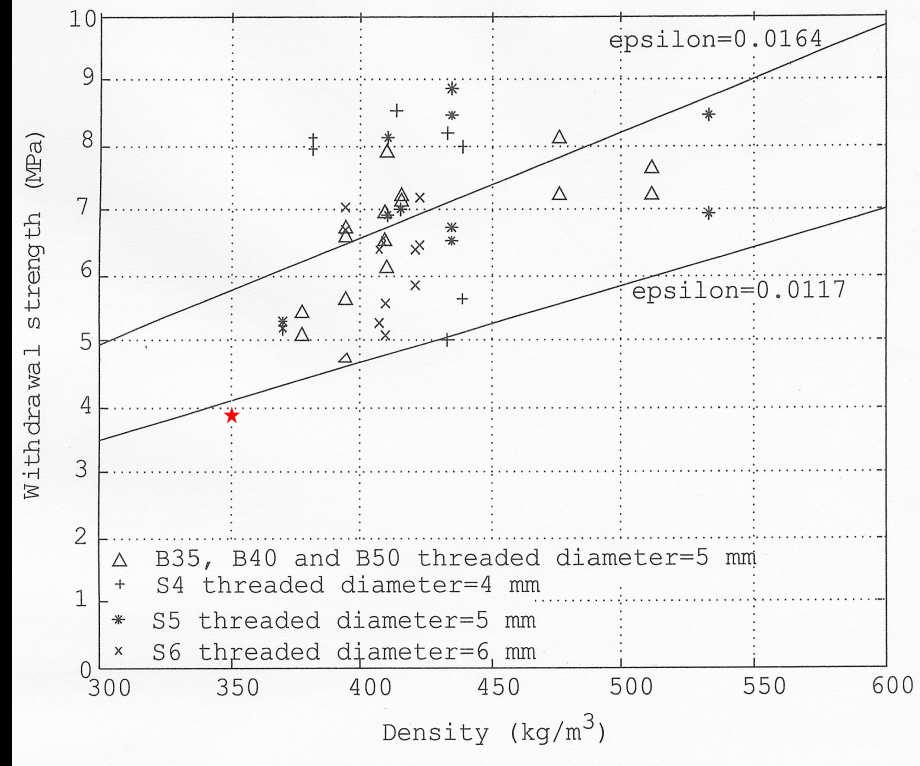
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- Danish code has $5d + \text{point}$

Withdrawal – screws 1

- Very complicated formula given and only for “old fashioned” screws with $d = 6-12$ mm
- The simple formula $0.035 d \ell_{\text{pen}} \rho$ can replace within 10% for $d = 6-10$ mm
- ITT will give a single strength parameter, independent on e.g. length. A possible diameter dependency will be included in declared parameter
- Separate spacing requirements for withdrawal and only for timber thickness $12d$ (which members thickness?)

Withdrawal – screws 2

- No significant dependency on diameter for $d = 4-6$ mm
- Connector screws and modern wood screws similar
- Fits well with (simplified) Eurocode formula



Laterally loaded fasteners

- Nails, timber to timber
- Screws, timber to timber
- Steel to timber

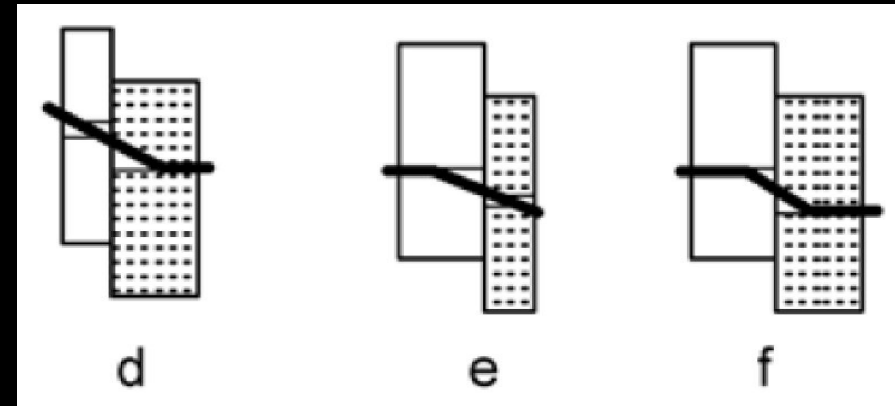
Laterally loaded nails – timber to timber

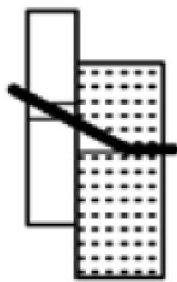
Eurocode:

- Dowel load capacity from Johansen-theory with embedment strength and yield moment of fastener
- Rope-effect from friction and inclination

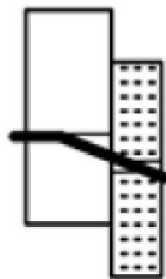
Danish code:

- Presupposes failure-mode f
 - mode e not possible due to required penetration length
 - mode d somewhat prevented by the head
- Rope-effect included by reduced penetration length for threaded nails

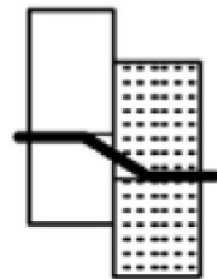




d



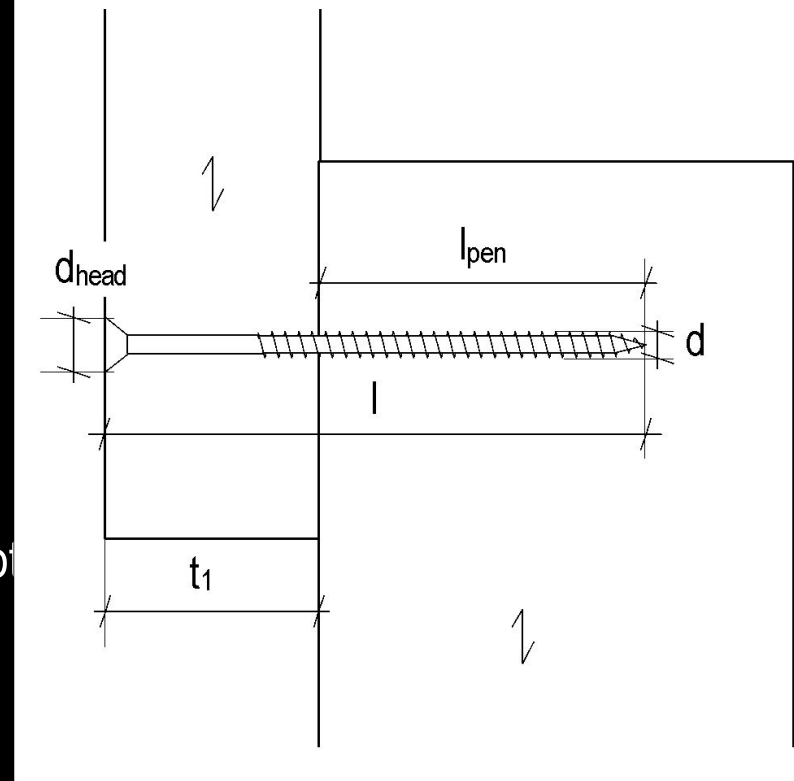
e



f

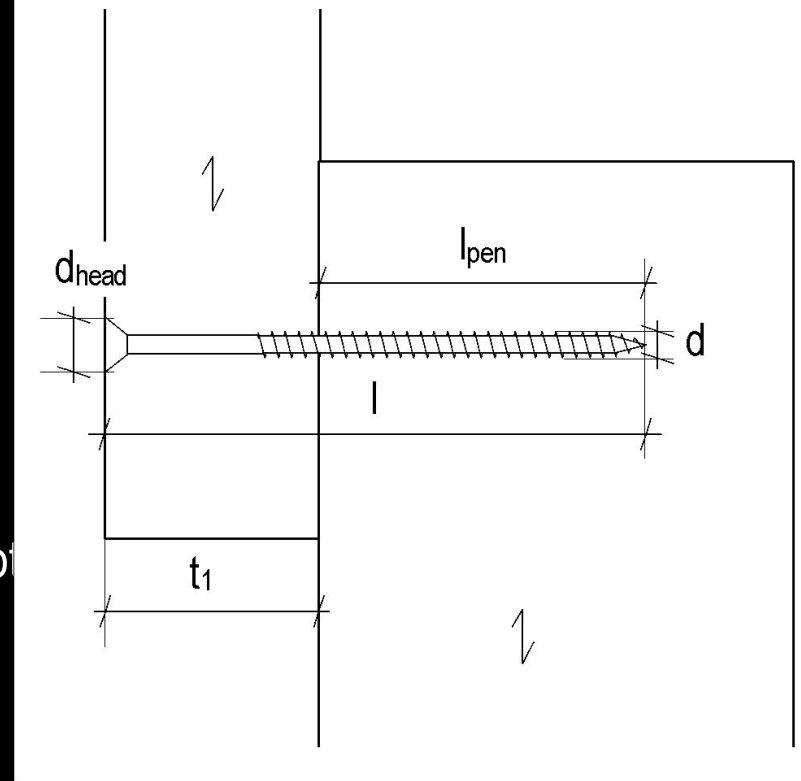
Laterally loaded screws

- Eurocode still focus on screws with smooth shank penetrating into pointside
- Eurocode suggests $d_{\text{eff}} = 1.1 \times d_{\text{root}}$ for the threaded part of screws



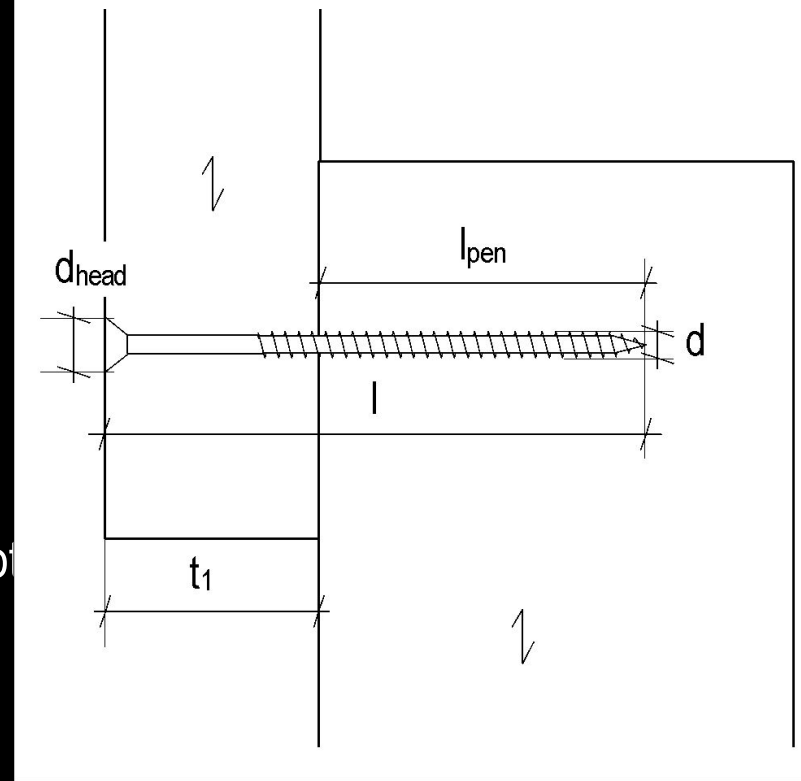
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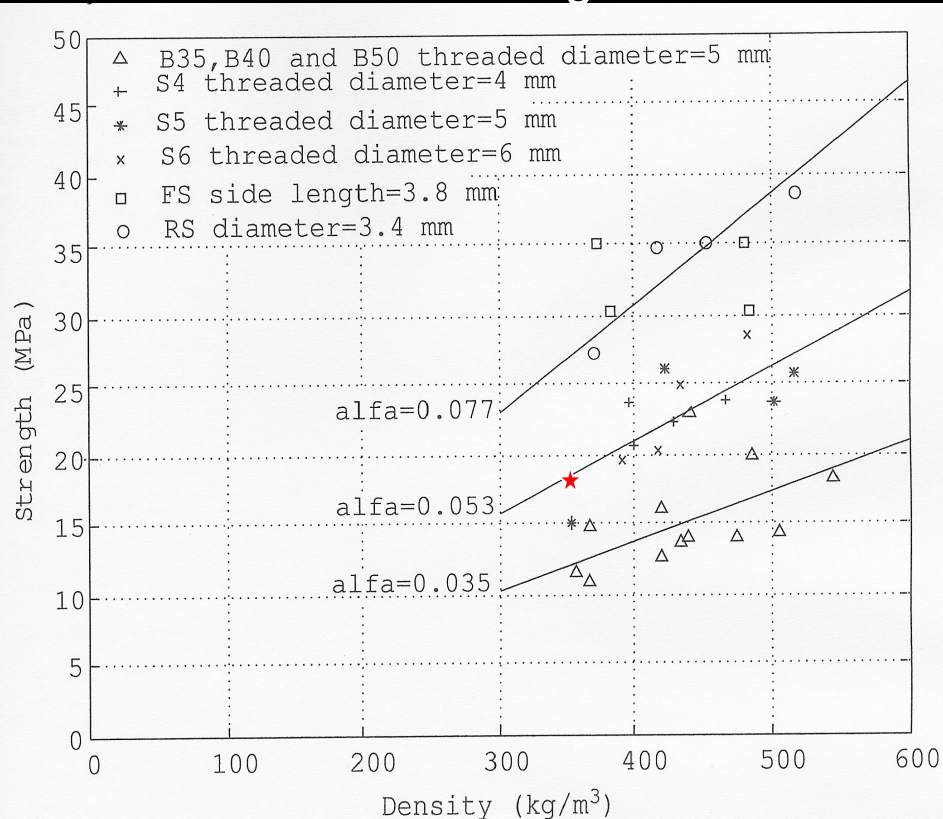
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- d_{eff} not likely to be the same for embedment strength f_h and yield moment M_y when measured
- prEN 14592 does not deal with neither d_{eff} nor f_h
- Most straight forward to declare f_h (for diameter d) and M_y



Measured embedment strength for screws

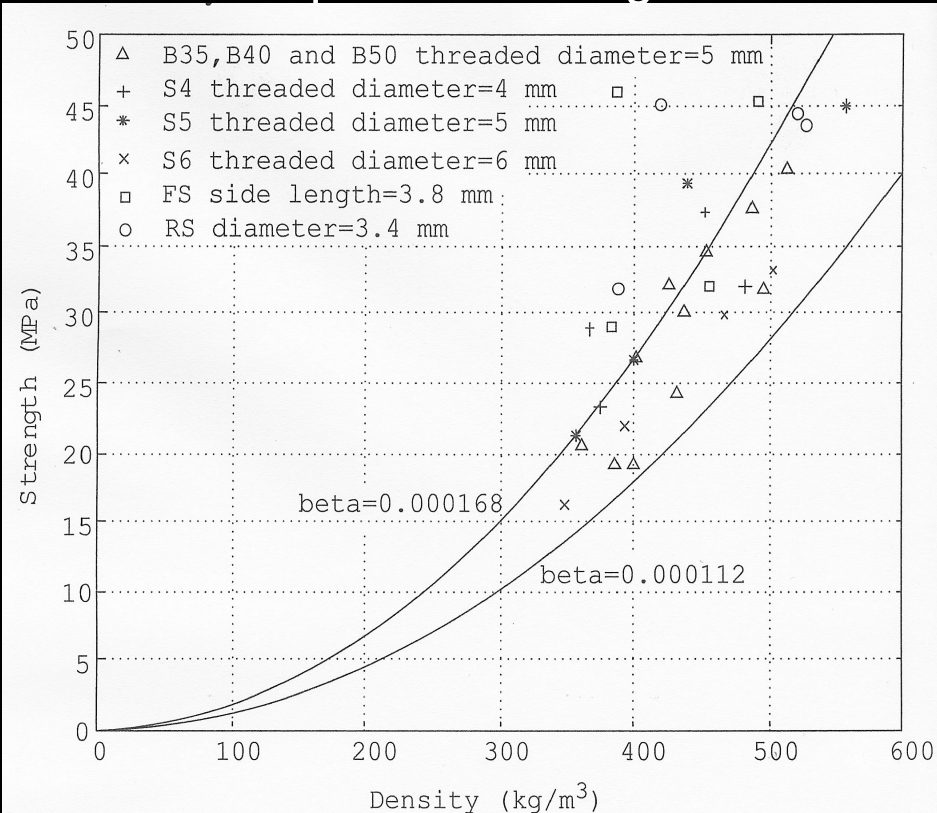
- $d_{\text{root}} / d \sim 0.6 \Rightarrow d_{\text{eff}} = 1.1 \times d_{\text{root}} = 0.66 d$
- Measured reduction factor for screws 0.45 – 0.7
- Hansen assumes factor to depend on surface roughness

Parallel to grain



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Perpendicular to grain



Laterally loaded nails - steel to timber

Eurocode:

- Separate formulas for thick and thin steel-plates (head fixed against rotation or not)
- Thick plate $t \geq d$, thin plate $t \leq d/2$

Danish code:

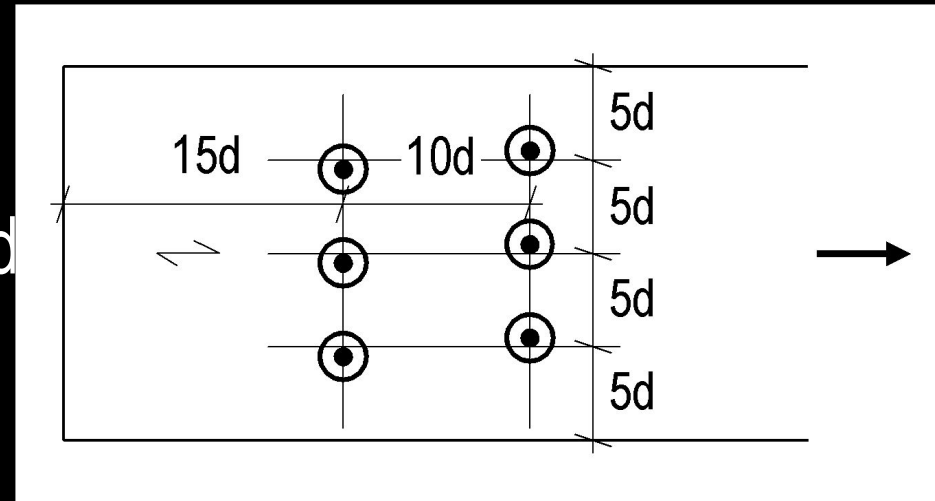
- Head assumed fixed against rotation
- Typical $d = 4 \text{ mm}$ and $t = 2 \text{ mm}$
- Timber to timber strength increased by 25 % (larger rope-effect when not pull-through)

TRZE

Higher values will appear in an ETA-agreement for most commonly used connector nails and screws (smaller penetration length, larger rope-effect, fixed head)

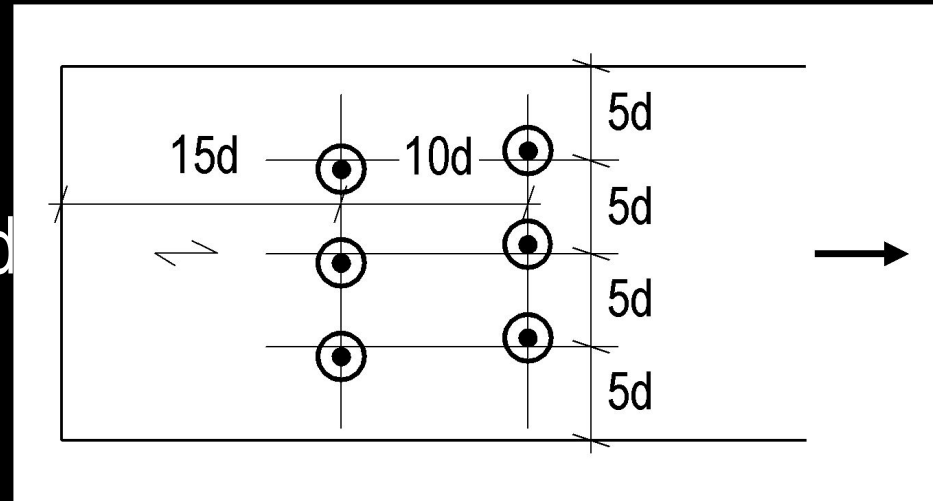
Spacing parallel to grain

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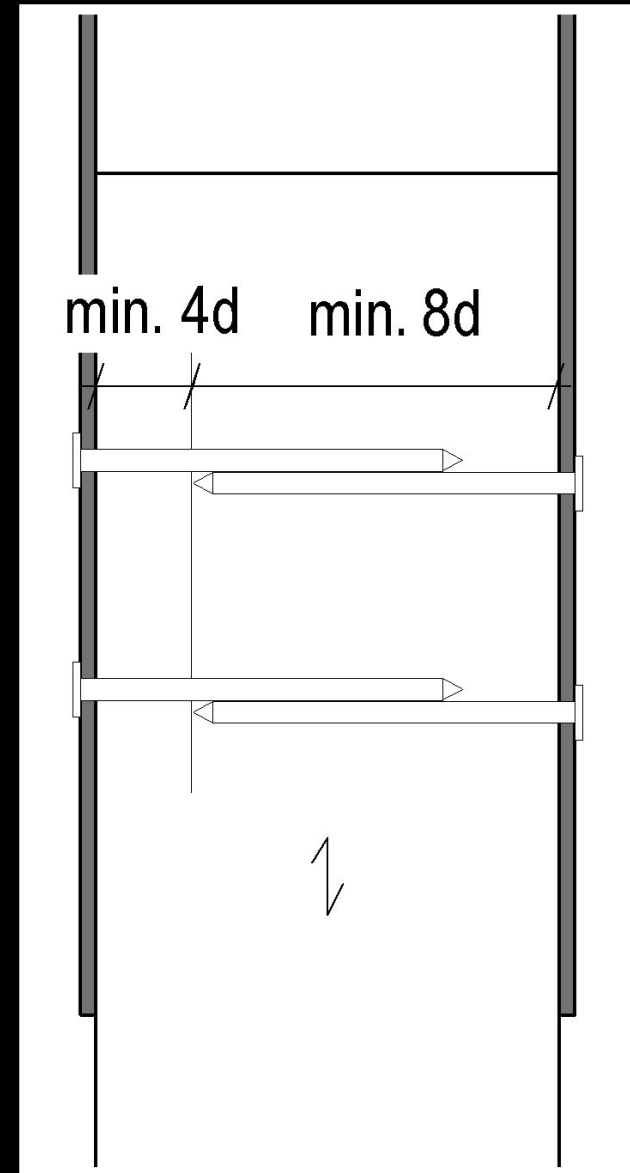


Steel connector plates:

- Spacing can be reduced by factor 0.7
- Not possible to stagger
- Not specified if increased spacing requirement can be reduced by 0.7
- Very questionable if staggering is meaningful for small diameters

Common connection not allowed by EC5

- 45 mm member with connector-plates on both sides
- Eurocode requires 4d from point to opposite site
Minimum member thickens for $d = 4$ mm:
 $(4 + 8)d = 48$ mm
- Danish code requires only 3d from point to opposite site



Conclusions 1

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- For types of fasteners covered by Eurocode 5 the strength parameters are **mostly** - but not always - conservative
- The dependency on density should in general be similar for nails and screws
- Strict rules are needed for correcting measured strength parameters for density
- Preferable to carry out tests with a natural span of densities rather than a fixed density

Conclusions 2

- Minimum penetration lengths appears very conservative
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- For screws **either** embedment strength for diameter of thread **or** effective diameter should be a declared parameter
- Spacing requirement in grain direction unnecessary and unclear for connector plates
- Replacing the Danish timber code with Eurocode 5 reduces the load capacities of most fasteners significantly
- Rules for two-sided nailing a catastrophe for Danish construction