Timber in Construction

Fire Safety developments in France

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Euroclass correspondance - *2002*

Fire resistance - *2004*

DTU Bois-Feu 88 ? ⟹ **EC5-1.2**

Existing rules

Normal situation : CB71 *(allowable stresses)*

Fire situation :

$e_{reduced} \geq 20$ mm

$t_{fi} = 30$ mn ⇨ $t_{timber} \geq 72$ mm ***(ou 62mm)***

$t_{steel} \geq 6$ mm ***(ou 4mm)***

Criteria :

Reduced capacity ≥ Allowable capacity x (1,75 to 2,25)

Elastic limit

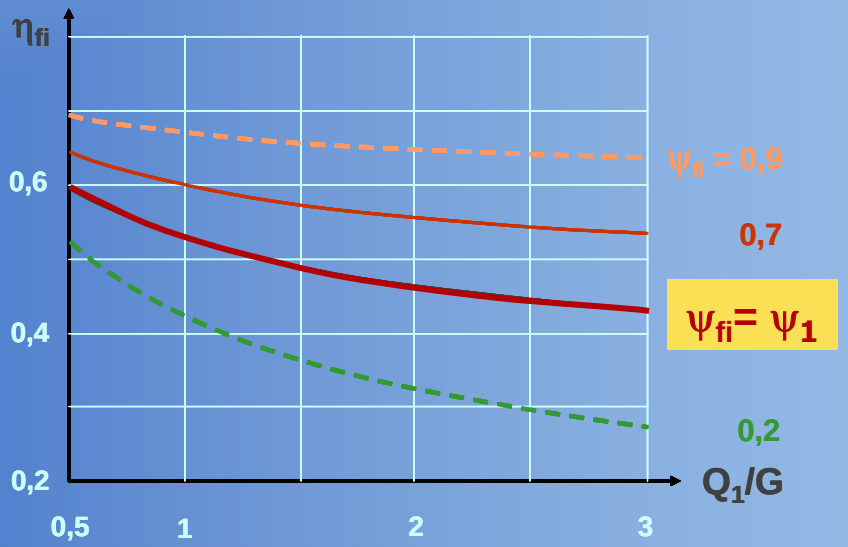
2004 regulations

Natural fire : Fire safety engineering possible control by agreed service (CSTB, CTICM)

Standardised fire :

Time	$t_{fi,d}$	$\geq t_{fi,req}$
Action effects	$R_{fi,d,t}$	$\geq E_{fi,d,t}$
Temperature	$\theta_{cr,d}$	$\geq \theta_d$

$$E_{fi,d,t} = \eta_{fi} E_d$$



$$G + \psi_{fi} Q_1$$

I – Fire resistance of common connections :

Timber to timber and steel to timber

F_d varying from 120 to 220 kN

Calibration of load level in fire :

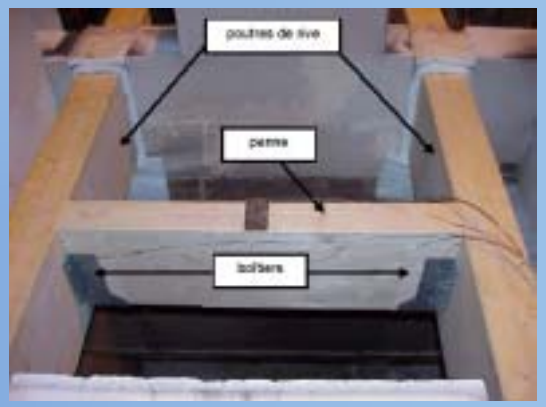
average of 3 ‘ cold ’ tests

Study of specific connections *(3D nailing plates)*

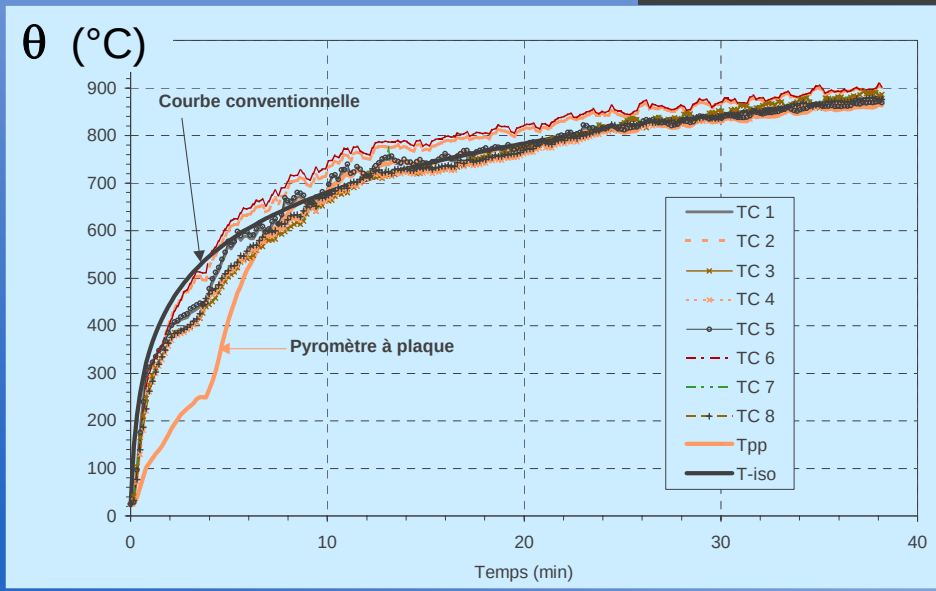
With support from industry (Aginco, Simpson)

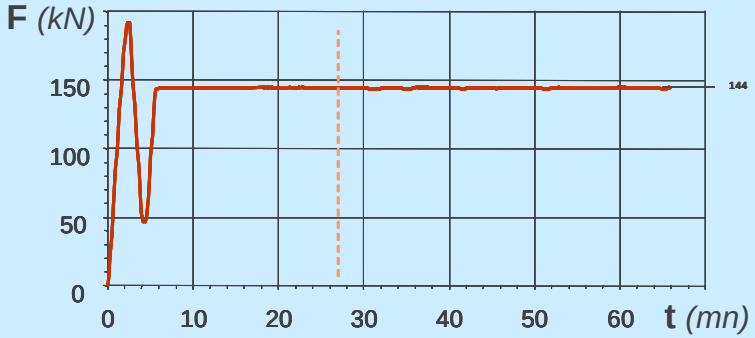
Some results

Testing arrangement

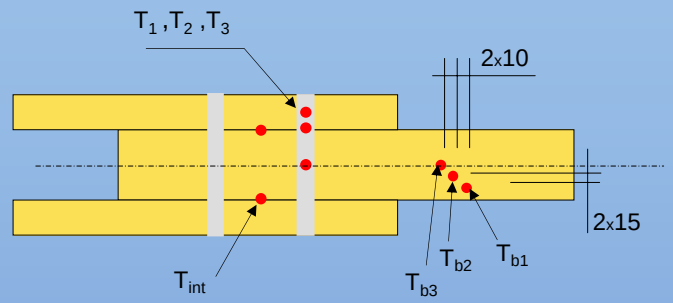


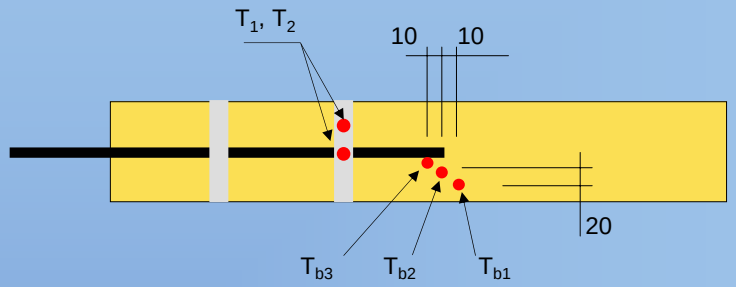
Test procedure



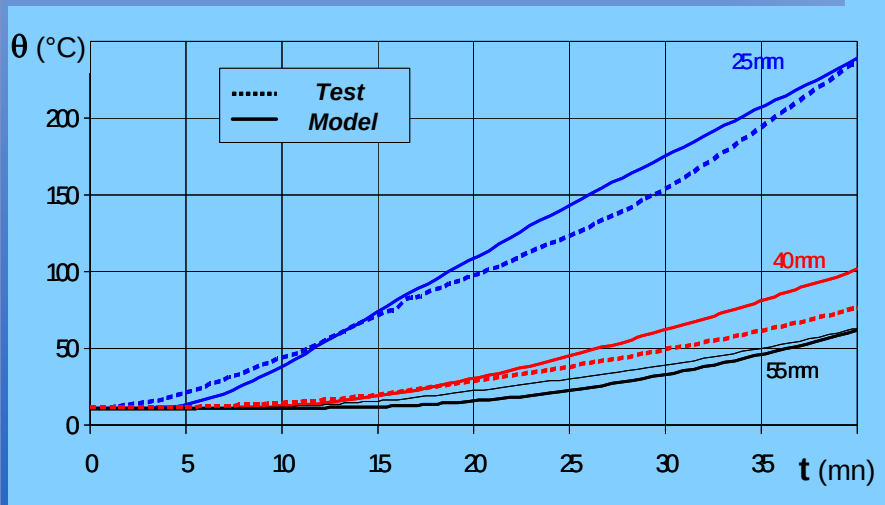


Temperatures

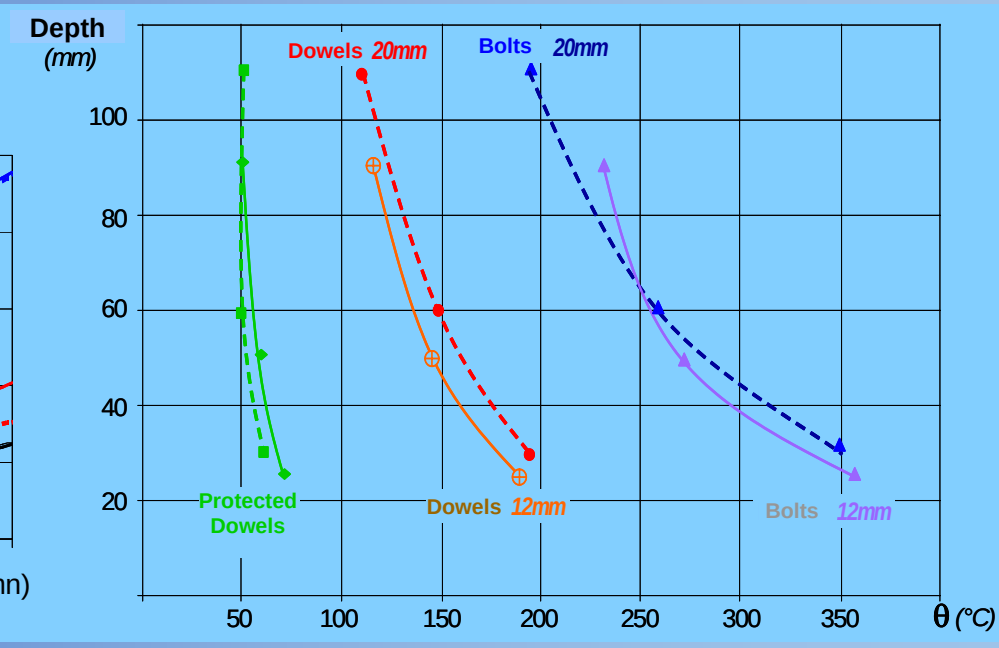




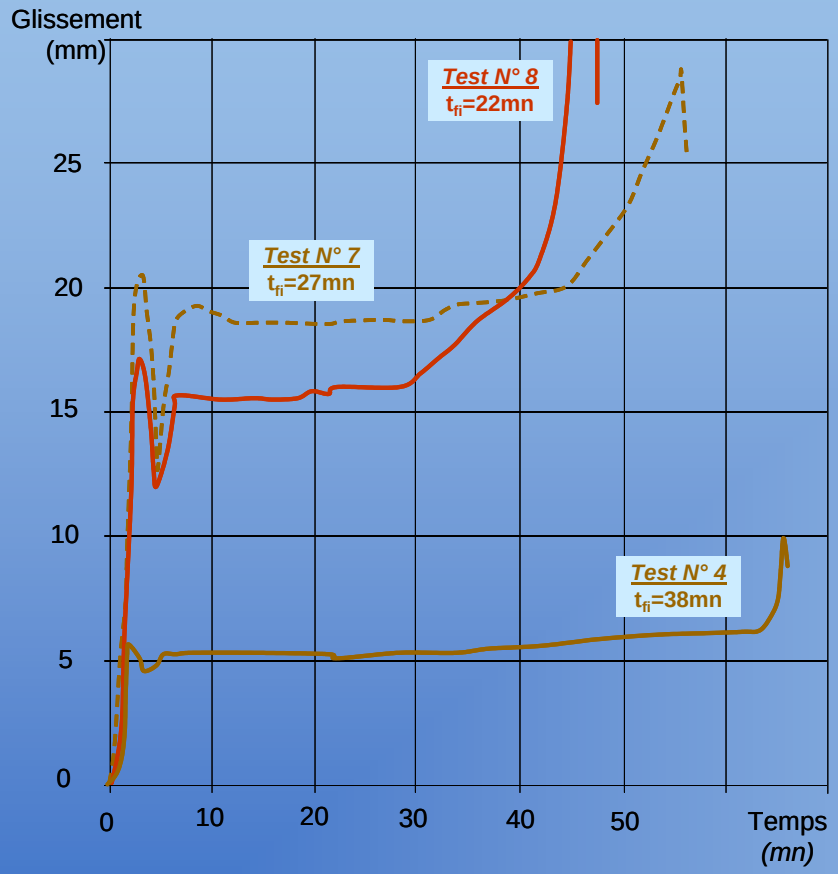
Timber



Fasteners

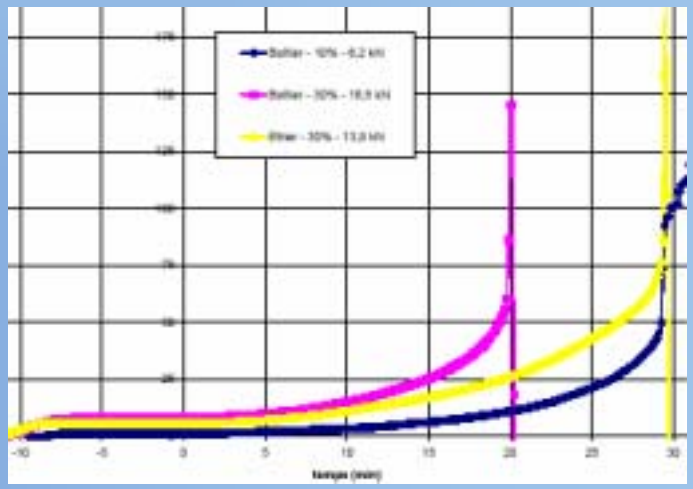


Joint stiffness k(θ)



Timber to timber and steel to timber joints

$K_{fi} = K_{ser}\ 0{,}67$



Joist hangers

$K_{fi} = K_{ser}\ 0{,}33$

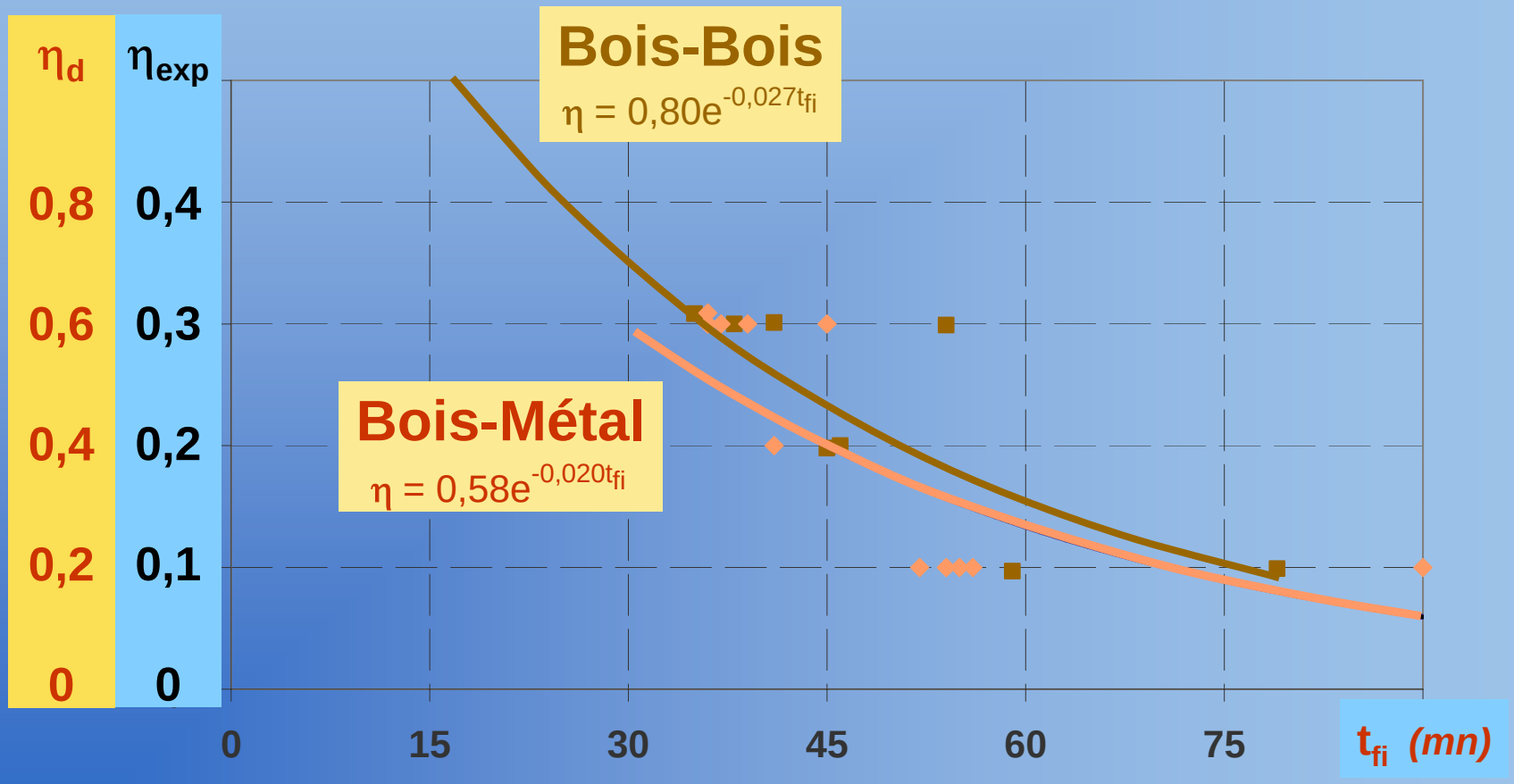
Failure modes

Timber to timber

Steel to timber

Joist hangers

Time to failure and loading ratio



Some conclusions

- **Normal condition *(EN1995-1.1)***

  $n_{ef} = n$ + **Annex A EN1995-1.1**

  Steel plates : Capacity of the net section

- **Fire situation**

  Timber joints ⇔ Stability > 1 hour (R90)

  $K_{fi} = K_{ser}\, k_t$

  Load level : $\eta_{exp} = A \; e^{-B \; t_{fi}}$

Timber to timber joints	*A=0,8*	*B=0,027*
Steel to timber joints	*A=0,58*	*B=0,020*

3D nailing plates *(nails)* $\eta_{exp} = \left(-0{,}018\, t_{fi} + 0{,}66\right)$

II – Analysis of the separating function (Annexe E)

$$t_{ins} = \sum t_{ins,0,i} \; k_{pos} \; k_j$$

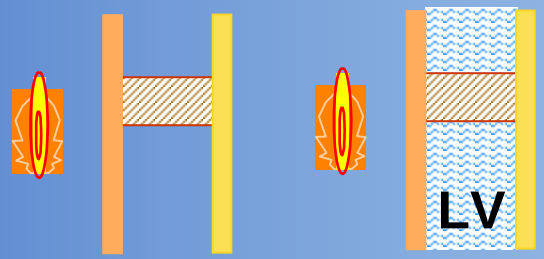
Basic Insulation Material i

$t_{ins,0} = h_p \times$

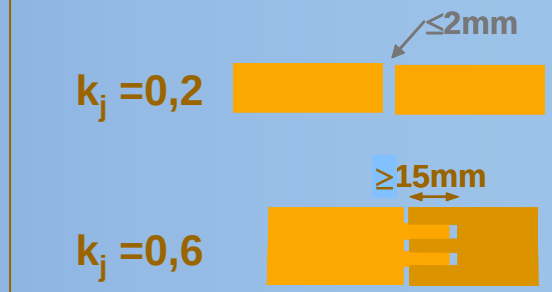
0,95	*Plywood*
1,10	*OSB*
1,40	*Gypsum*
0,10 k_{dens}	*LV*

LR = 2 x LV

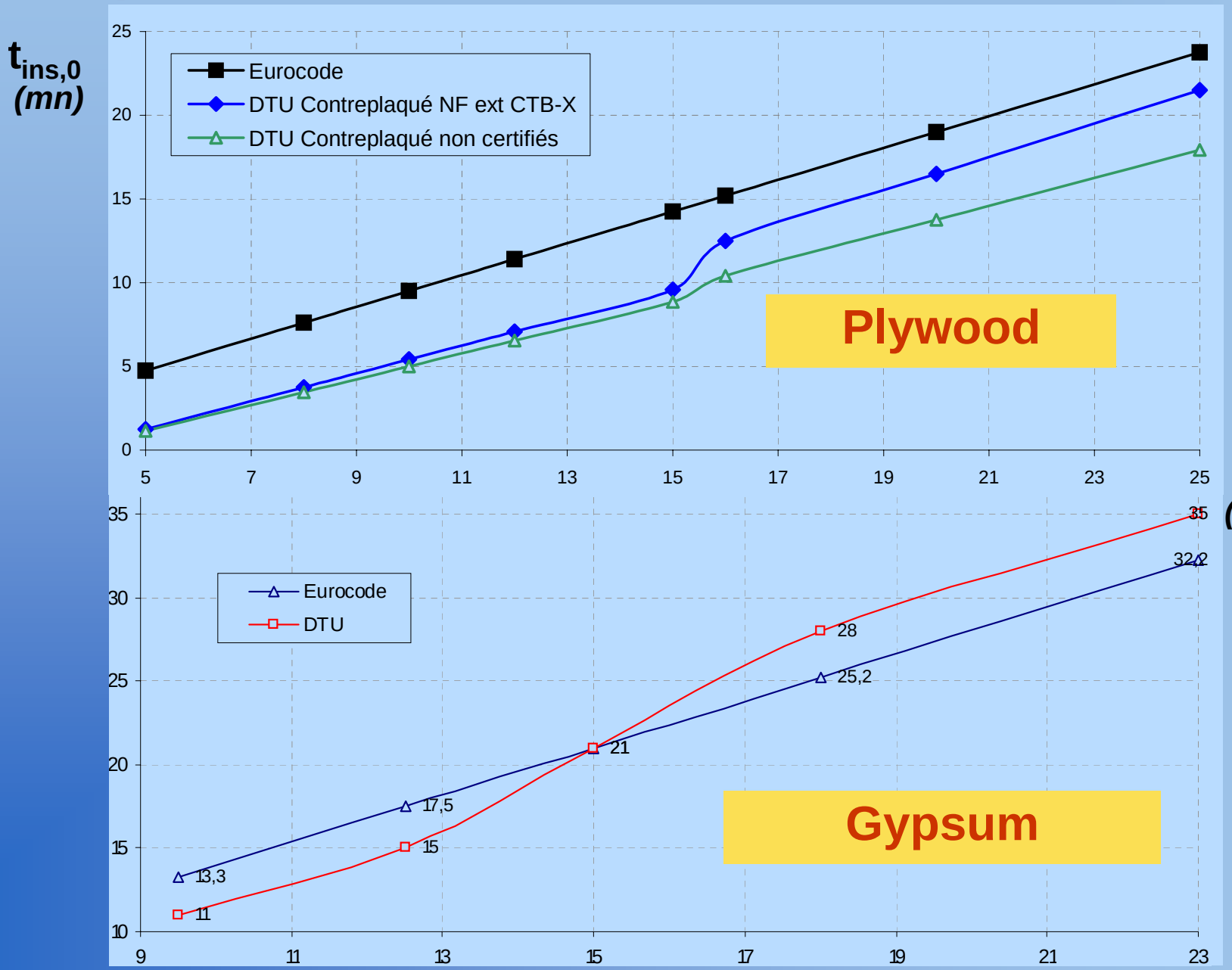
Position



Joint

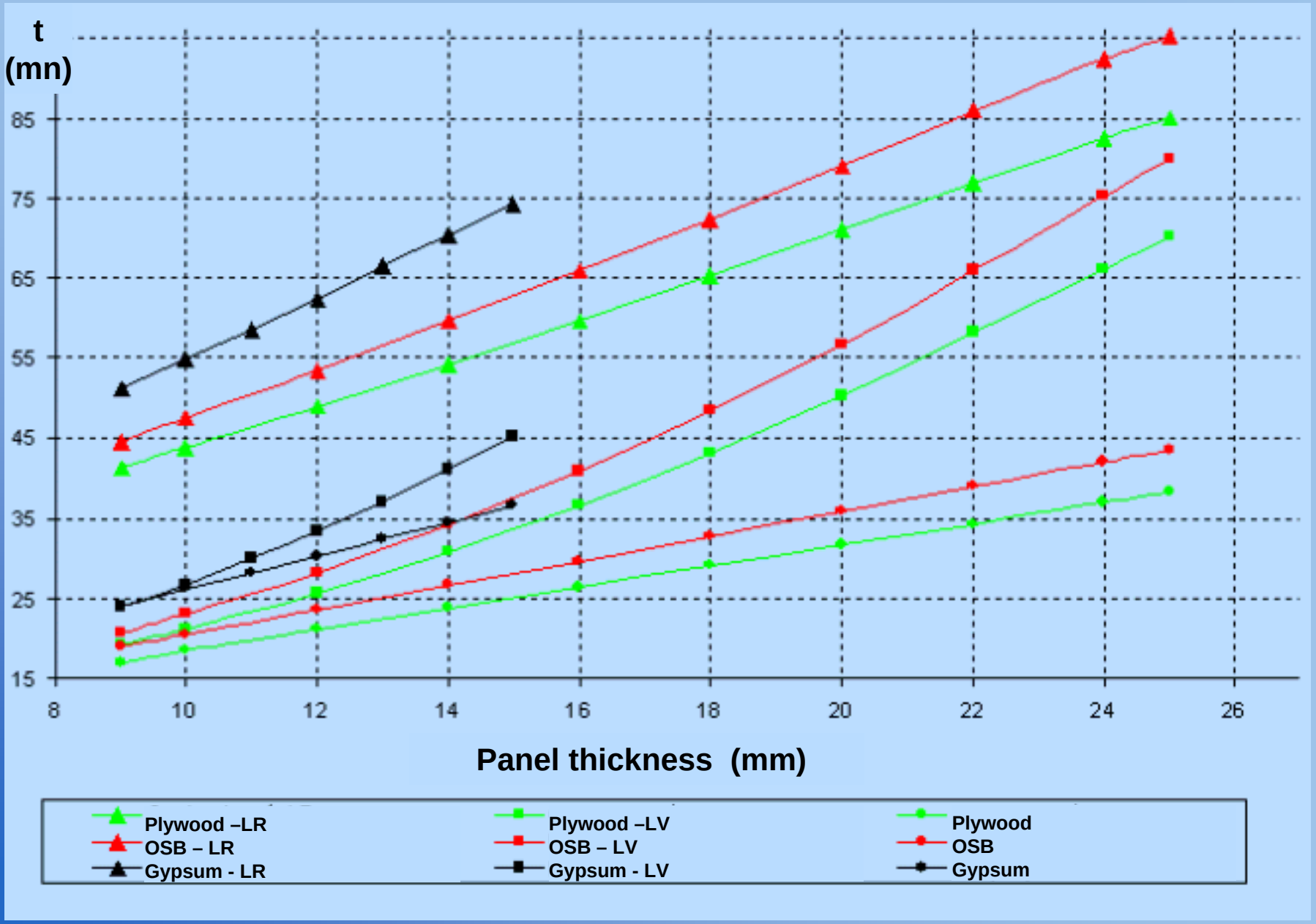


Comparison Eurocode-DTU

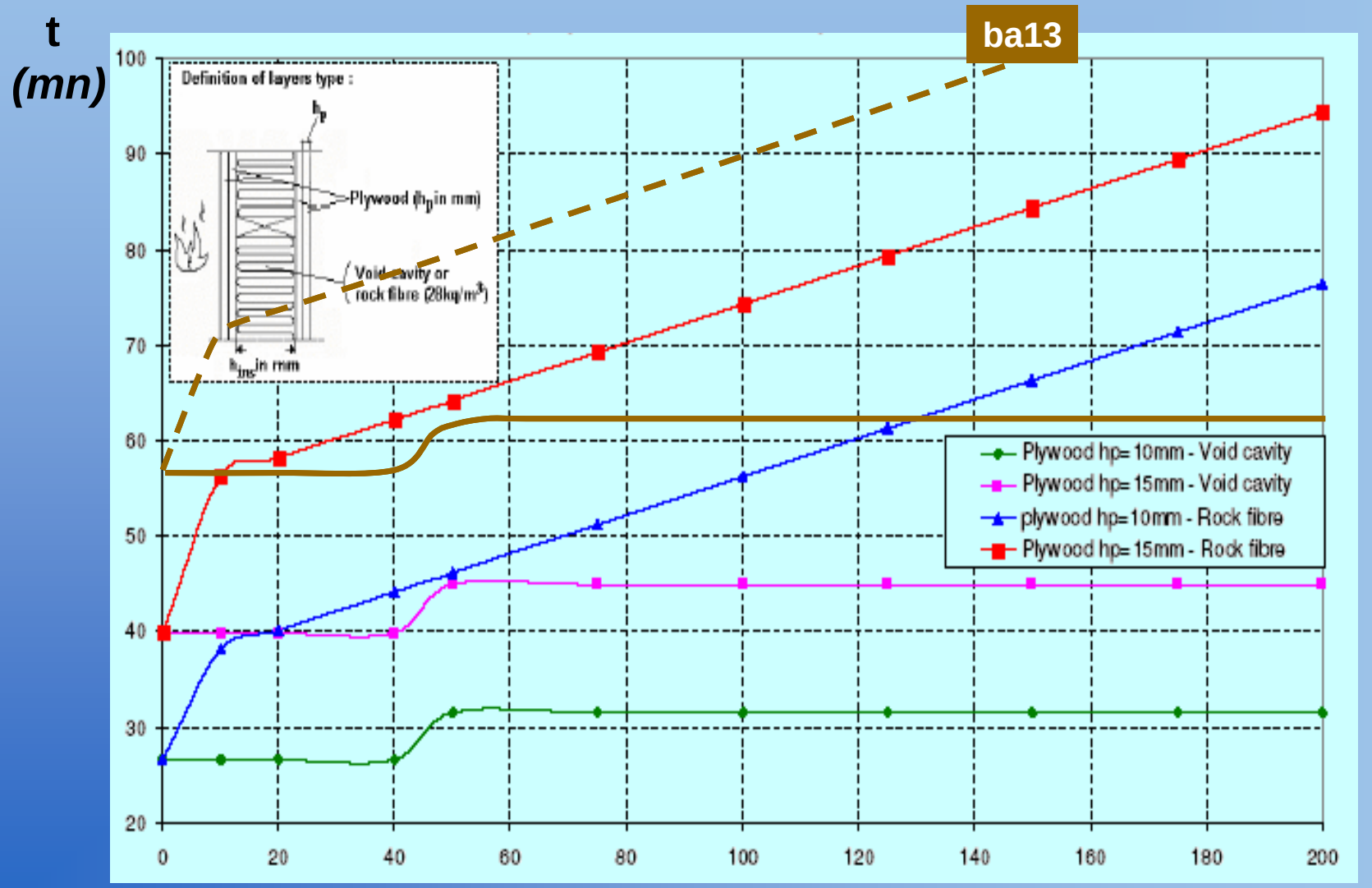


R&D - 2

WALL - cavity = 100mm



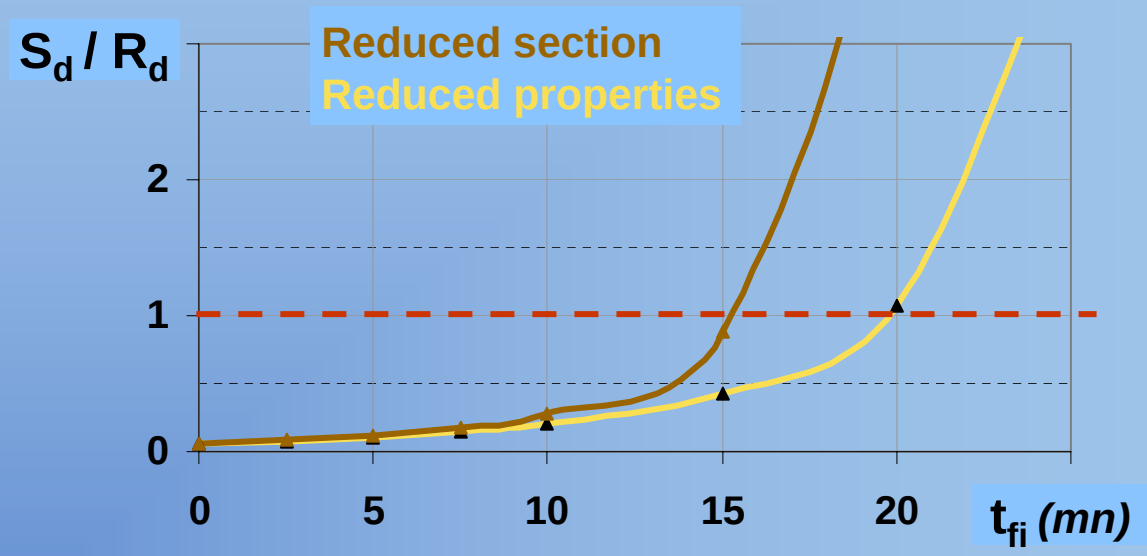
Cavity depth effect



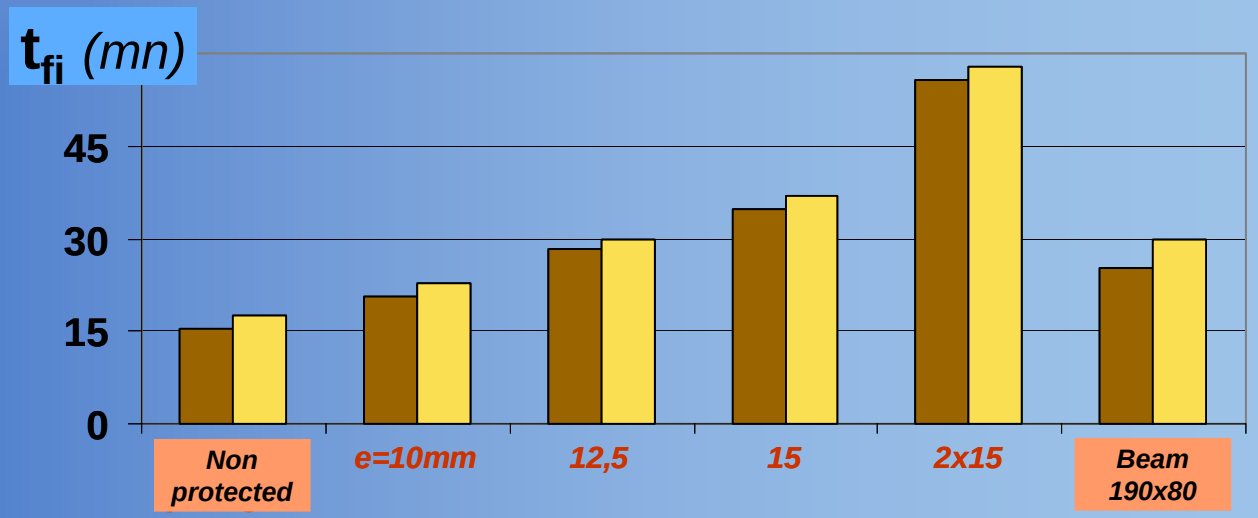
Protection of structural elements

Beam C24 (60x180)mm²

Non protected



Protection effect



Next actions in France …

At the code level

National Annex EN1995-1.2 *(20-9-05) …*

…to be included in fire resistance regulations

*« **Europe Plan** » and « **Eurocodes Project** »:*

Simplified design rules for EN1991 / 1998

Timber components : Separating function under fire
Connection design

At the R&D level

Thermo-mechanical modelling of dowelled connections

(Thesis K.Laplanche)

National Project « Fire safety engineering »

Safety criteria – human behaviour

Risk analysis

Fire modelling

Mechanical modelling….

*Concrete, Steel, **Timber**, Glasses…*