



Timber in Construction

Fire Safety developments in France

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Euroclass correspondance - 2002

Fire resistance - 2004



■ Existing rules

Normal situation : CB71 (*allowable stresses*)

Fire situation :

$$e_{\text{reduced}} \geq 20 \text{ mm}$$

$$t_{\text{fi}} = 30 \text{ mn} \quad \Rightarrow \quad t_{\text{timber}} \geq 72 \text{ mm (ou 62mm)}$$

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

Criteria :

$$\text{Reduced capacity} \geq \text{Allowable capacity} \times (1,75 \text{ to } 2,25)$$

Elastic limit

2004 regulations

Natural fire :

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

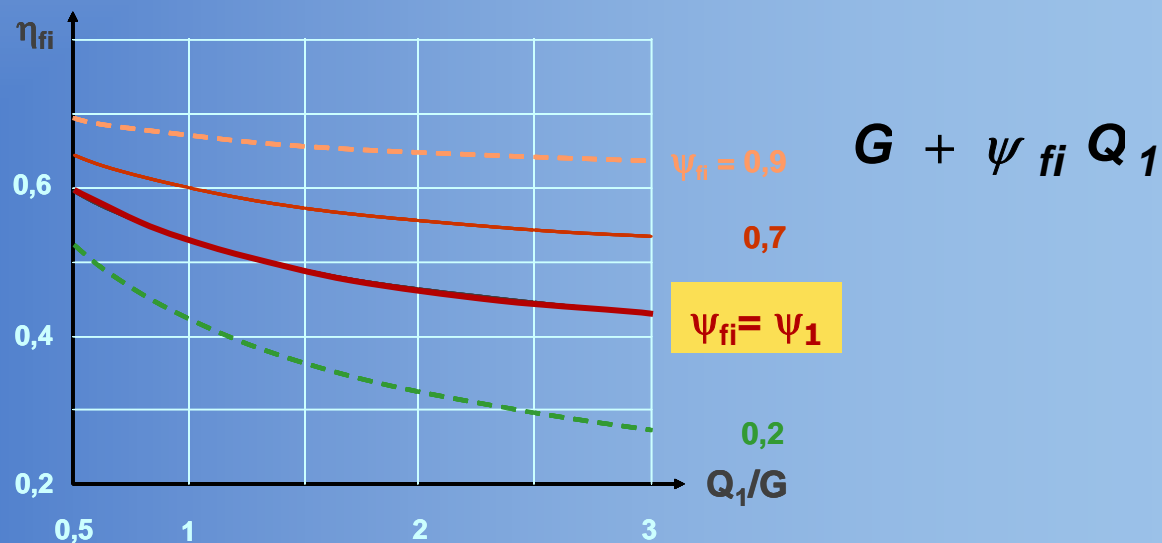
Standardised fire :

Time $t_{fi,d} \geq t_{fi,req}$

Action effects $R_{fi,d,t} \geq E_{fi,d,t}$

Temperature $\theta_{cr,d} \geq \theta_d$

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





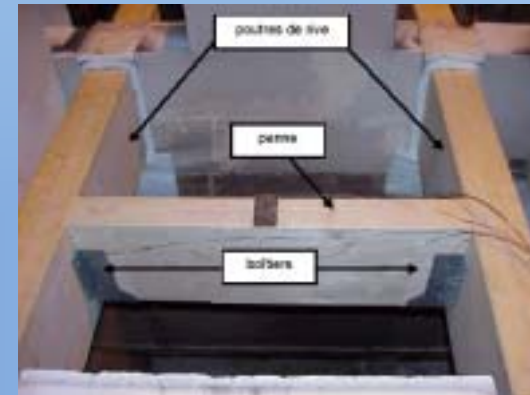
I – Fire resistance of common connections :
Timber to timber and steel to timber
 F_d varying from 120 to 220 kN

Calibration of load level in fire :
average of 3 ‘ cold ’ tests

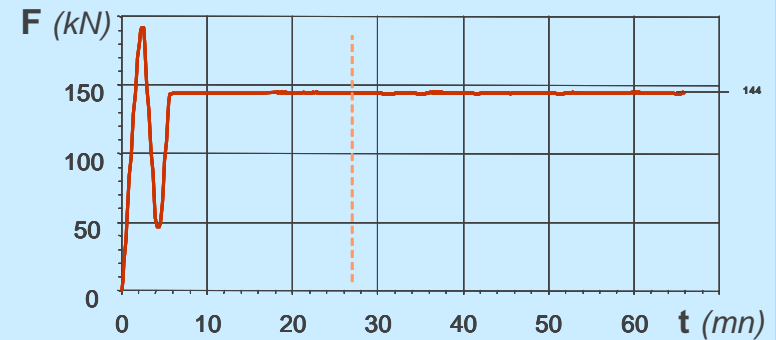
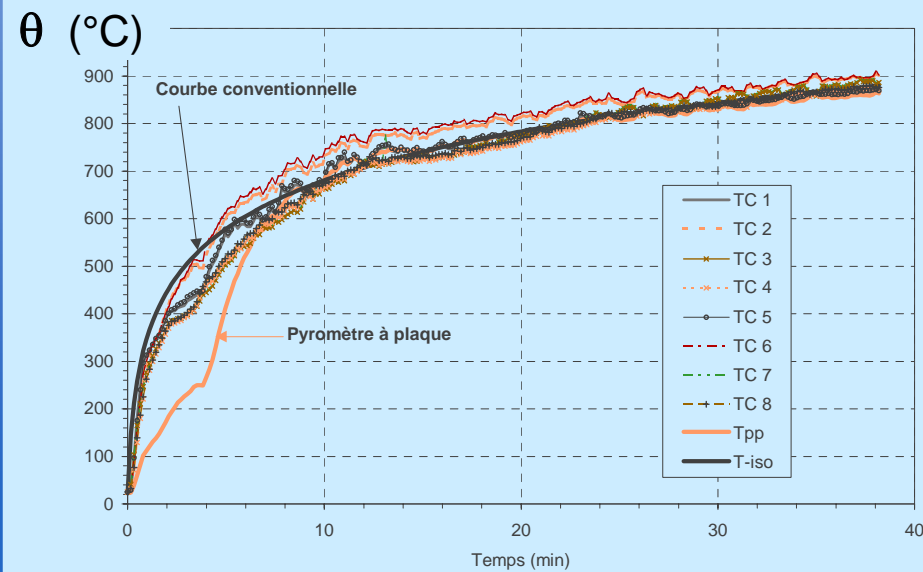
Study of specific connections (3D nailing plates)
With support from industry (Aginco, Simpson)

Some results

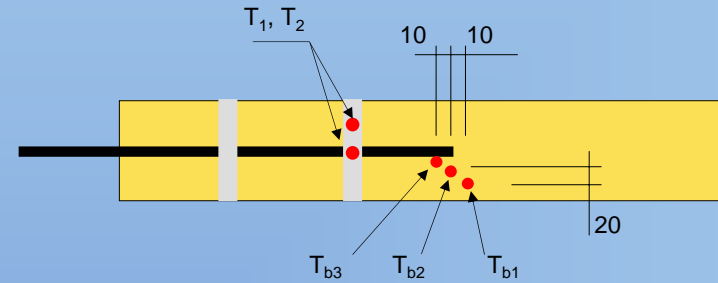
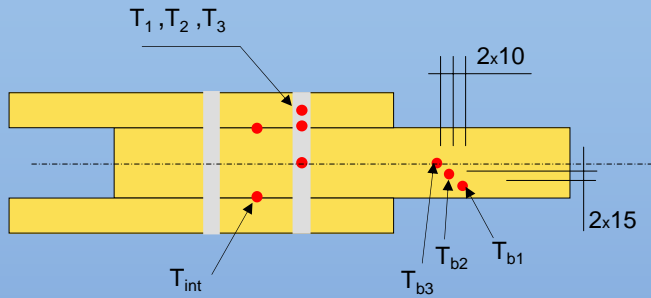
■ Testing arrangement



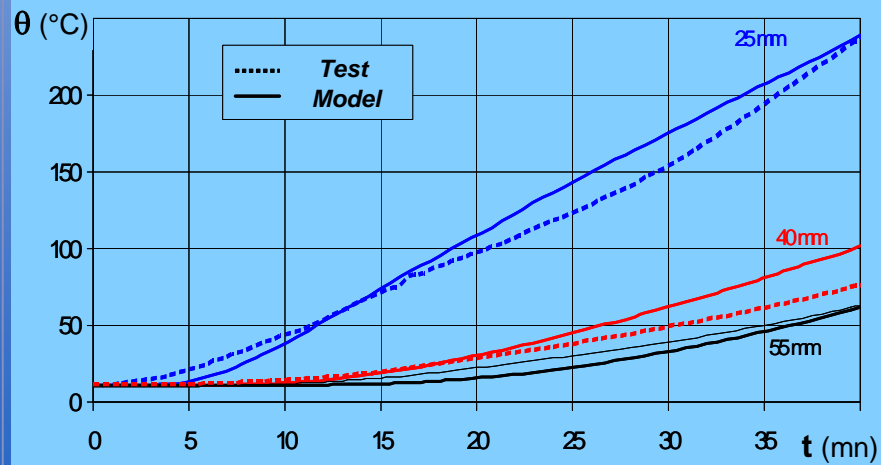
Test procedure



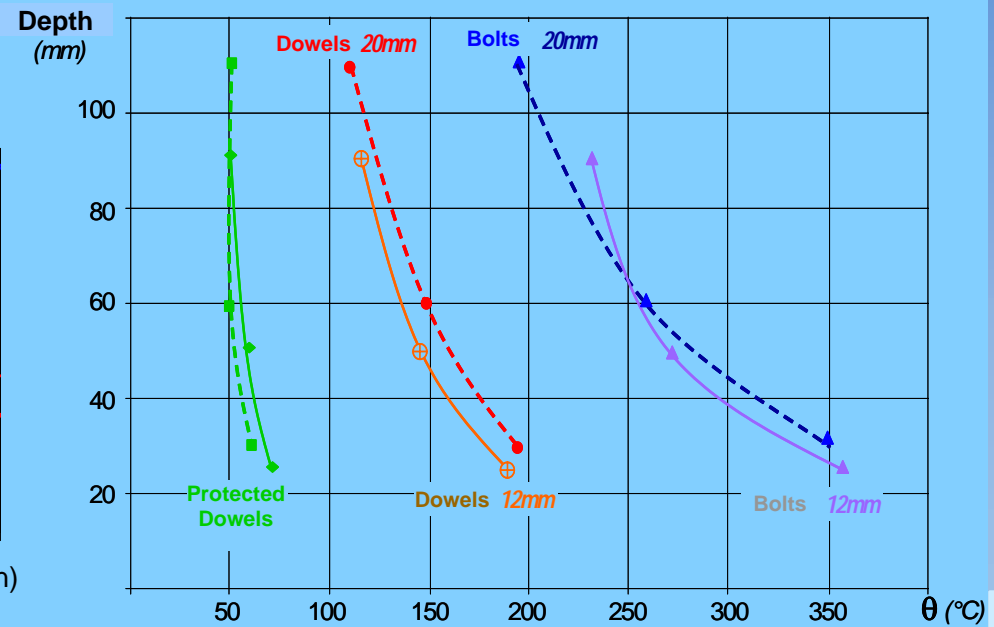
■ Temperatures



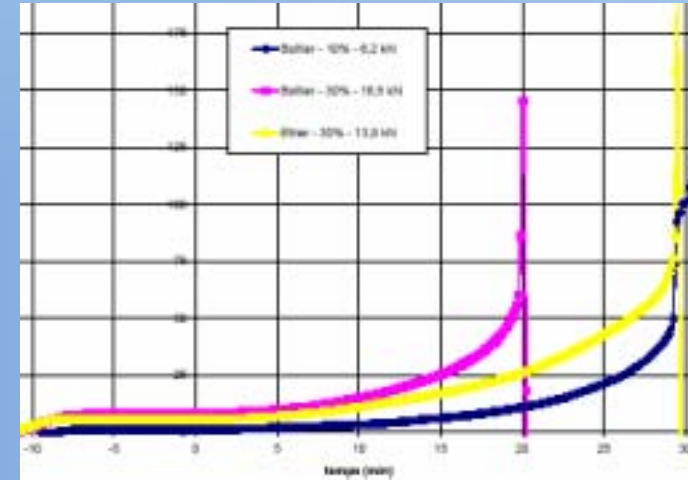
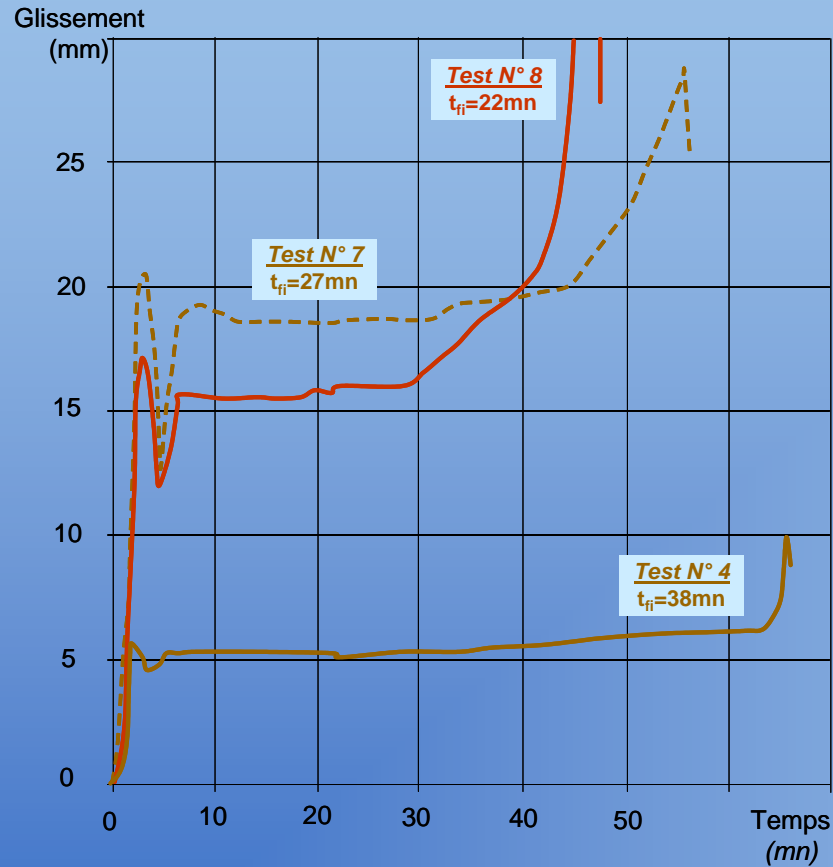
Timber



Fasteners



Joint stiffness $k(\theta)$



Joist hangers

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

Timber to timber and steel to timber joints

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

■ Failure modes

Timber to timber



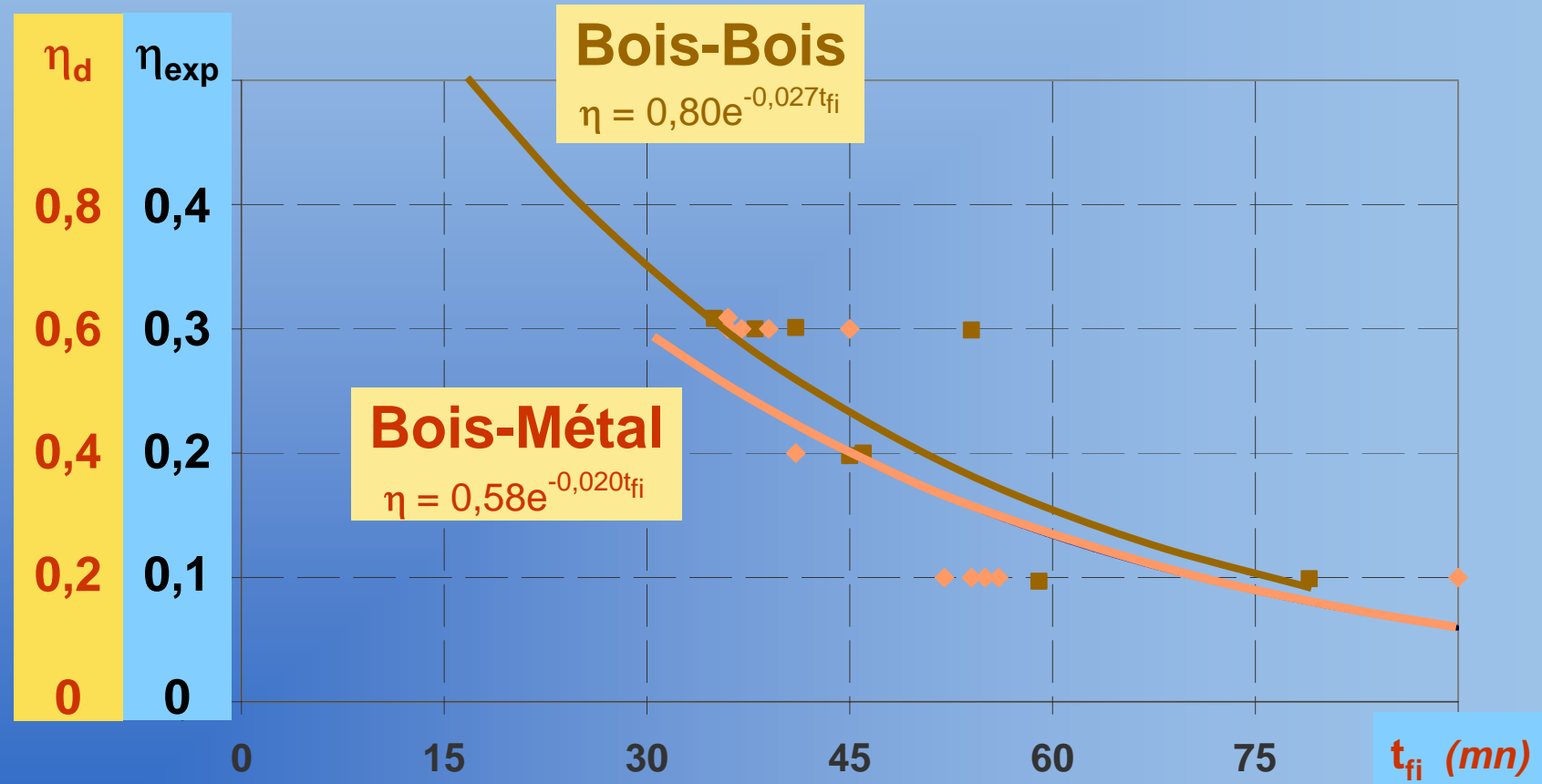
Steel to timber



Joist hangers



■ Time to failure and loading ratio



Some conclusions

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

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

Steel plates : Capacity of the net section

- **Fire situation**

Timber joints \Leftrightarrow 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*) $\eta_{exp} = (-0,018 t_{fi} + 0,66)$



II – Analysis of the separating function (Annexe E)

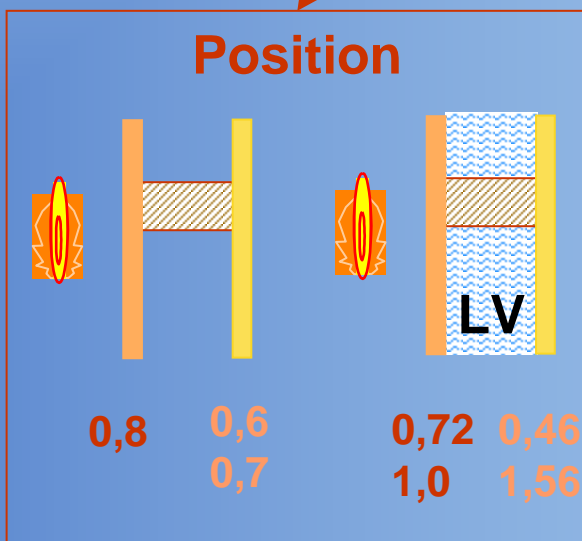
$$t_{ins} = \sum t_{ins,0,i} k_{pos} k_j$$

Basic Insulation Material i

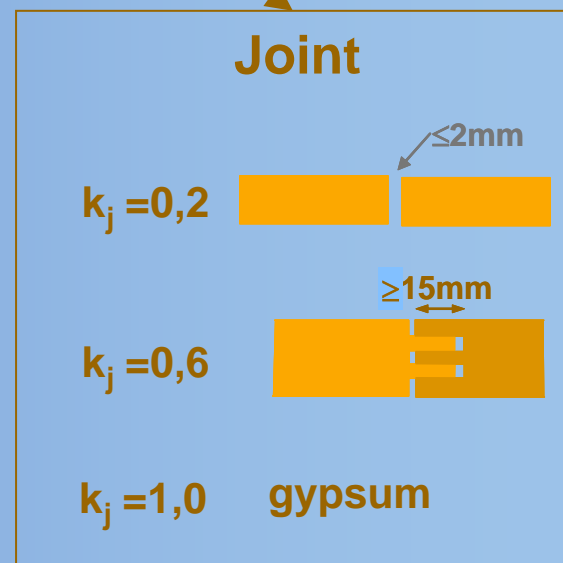
$$t_{ins,0} = h_p \times \begin{cases} 0,95 & \text{Plywood} \\ 1,10 & \text{OSB} \\ 1,40 & \text{Gypsum} \\ 0,10 k_{dens} & \text{LV} \end{cases}$$

$$LR = 2 \times LV$$

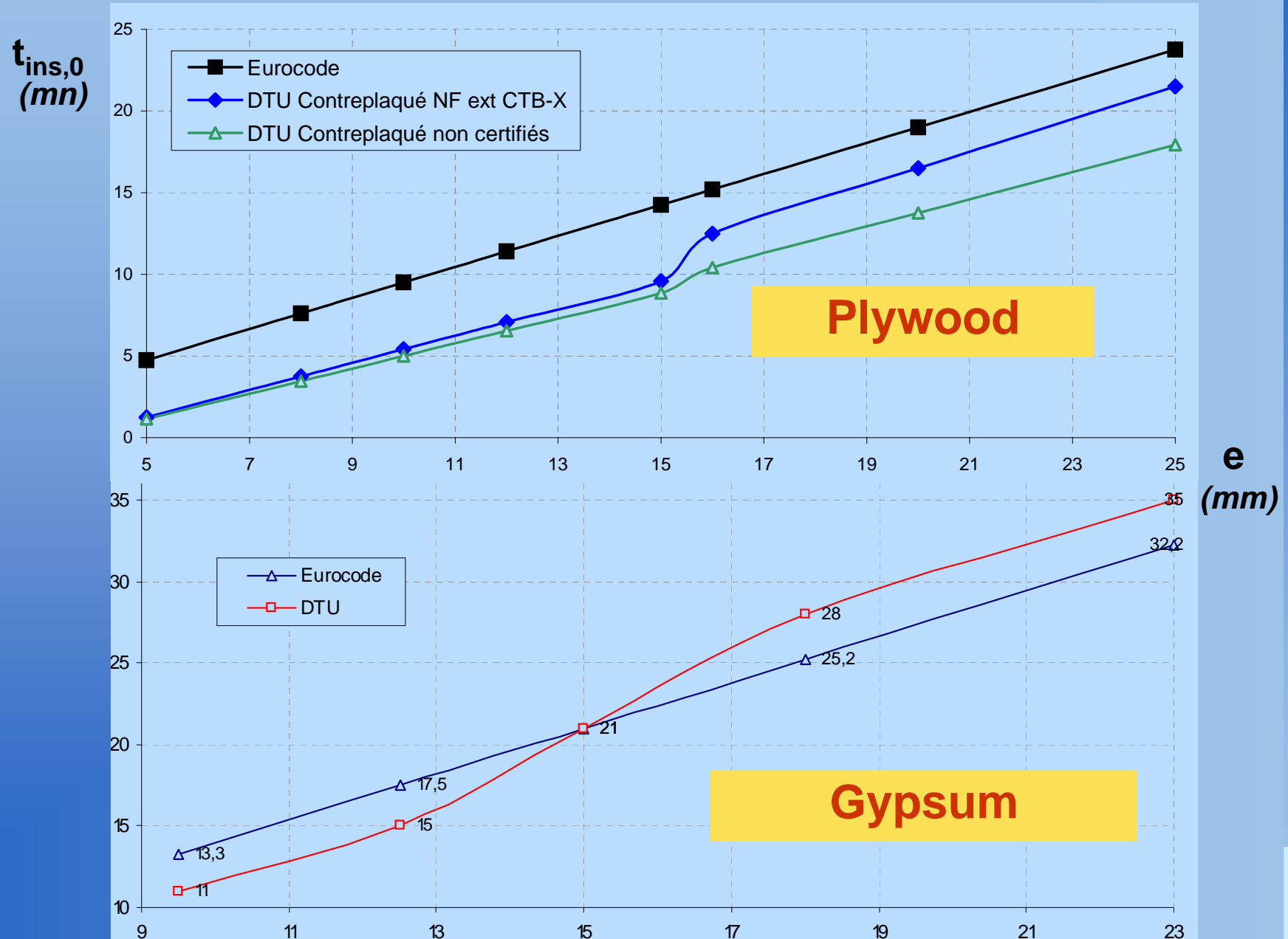
Position



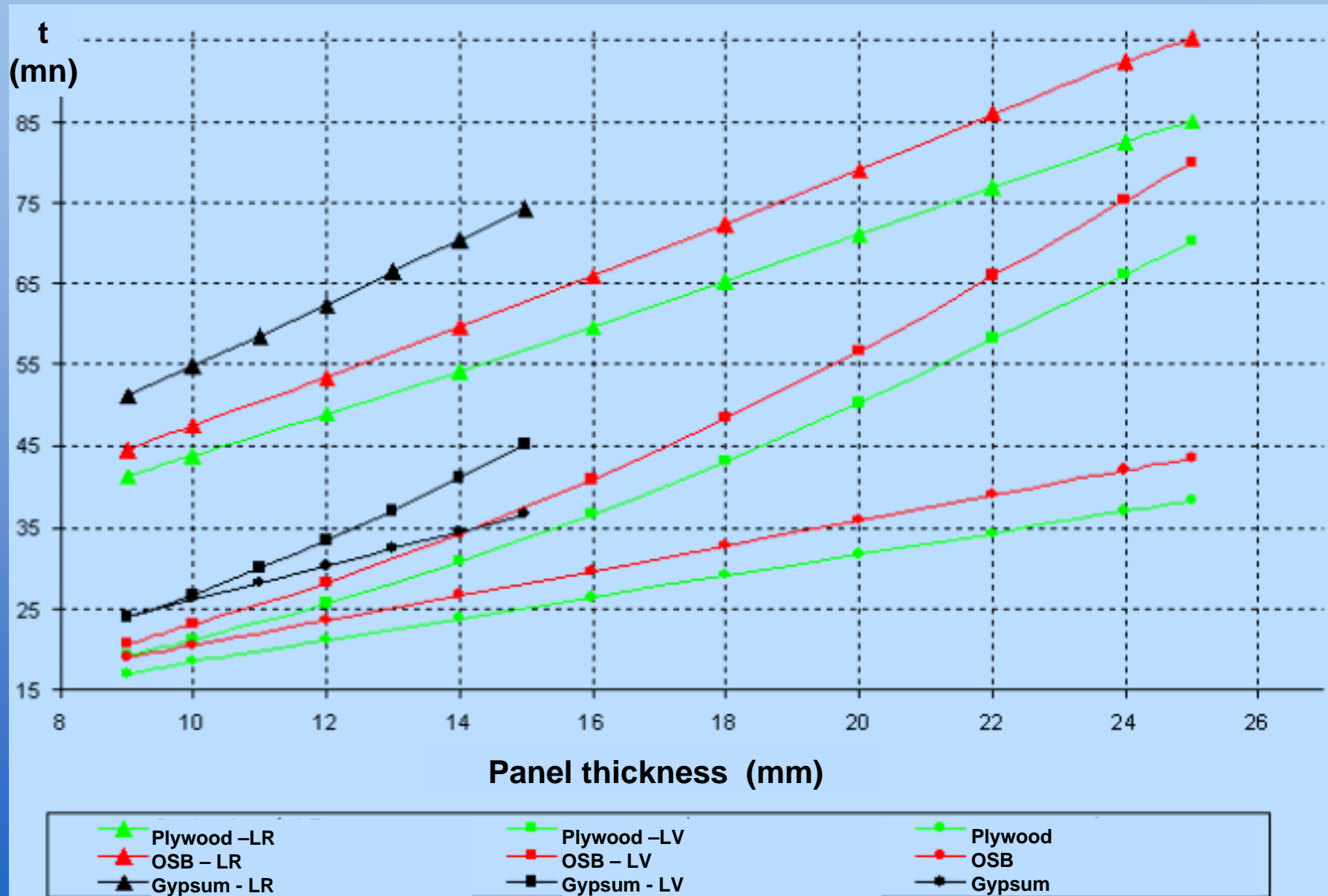
Joint



■ Comparison Eurocode-DTU

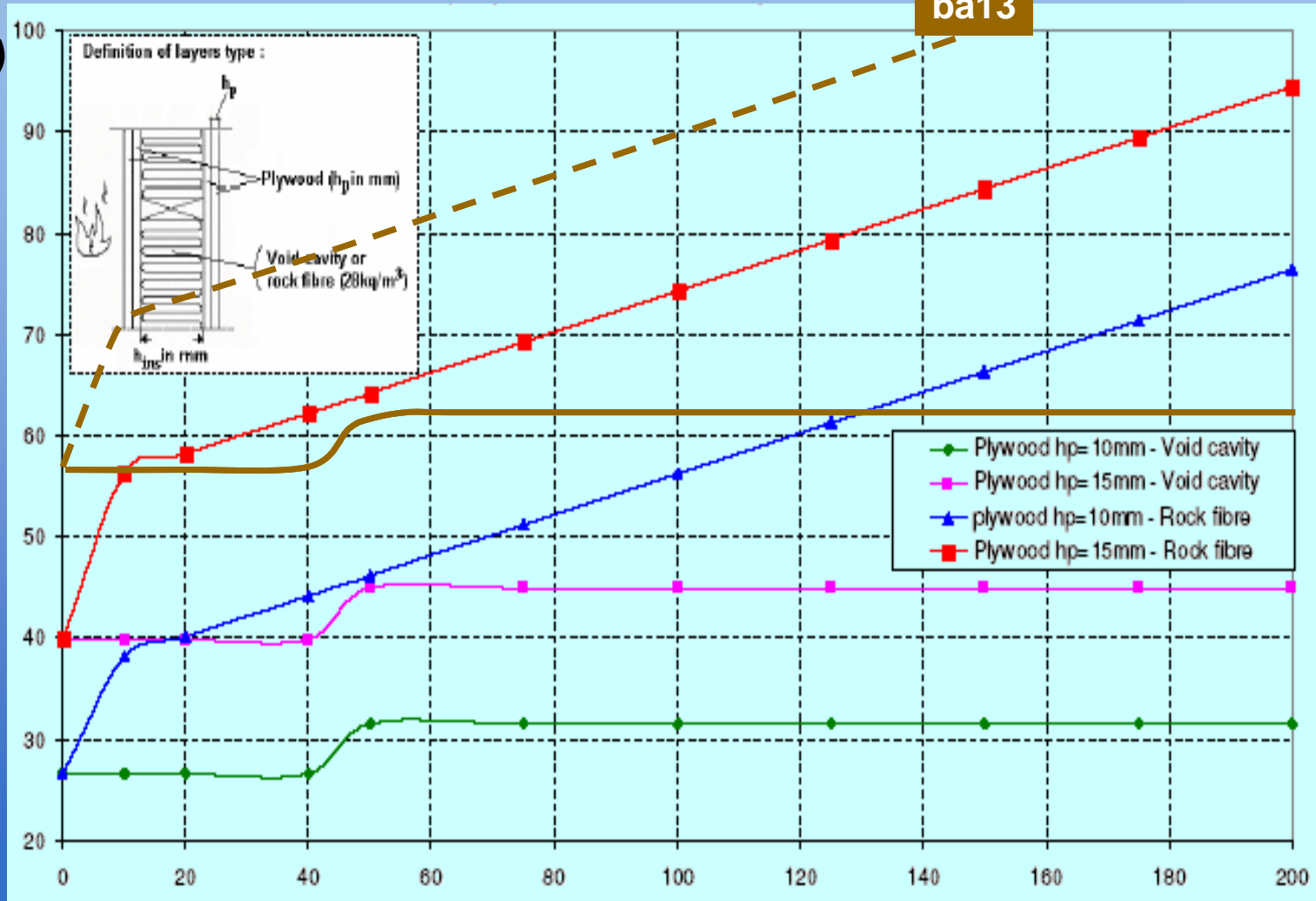


WALL - cavity = 100mm



■ Cavity depth effect

t
(mm)

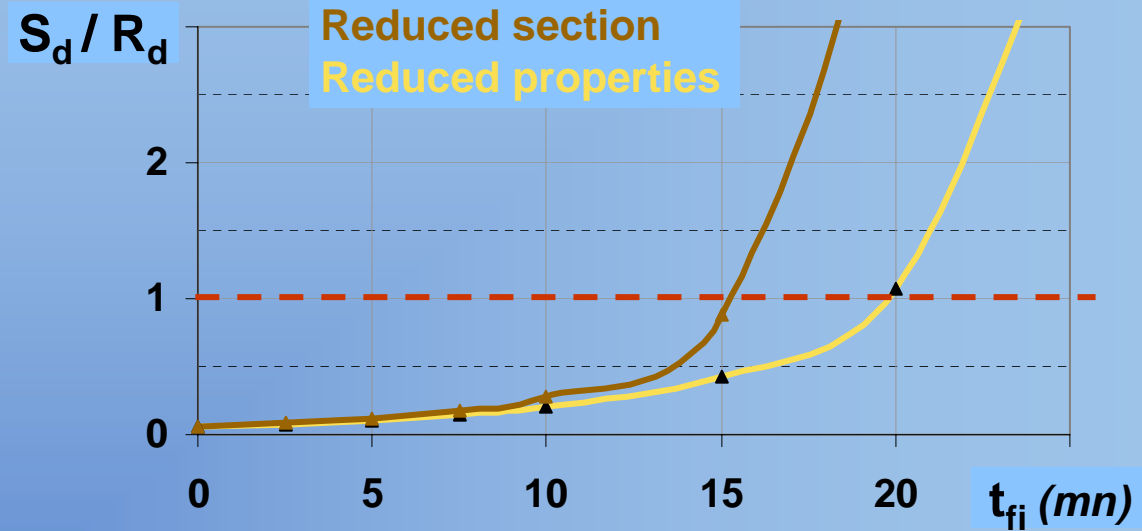


h_p (mm)

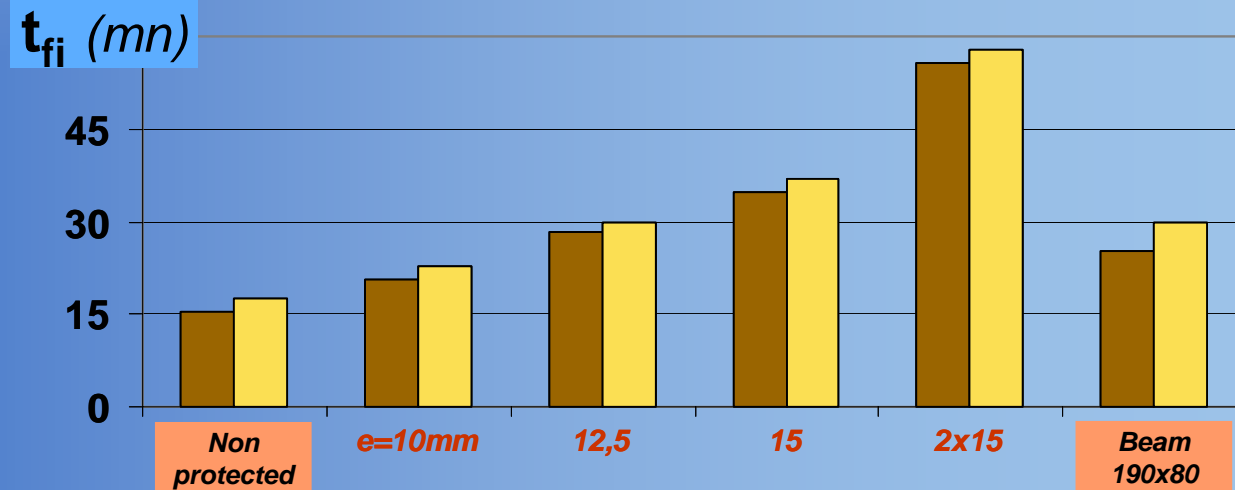
■ Protection of structural elements

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...

