A MCM for softwood exposed to parametric design fires- Background

- Thermal properties of timber not well defined for non-standard fires. EN 1995-1-2 gives guidance on λρc for ISO834 exposure only.
- Why? Because properties in EN 1995-1-2 are calibrated. Include lots of behavioural aspects implicitly. Behaviours are not independent of heating rate due to calibration!
- Reality, solid phase heat transfer not sufficient to characterise heat flow in timber, need mass transfer aspect, cracking & ablation. EN 1995-1-2- 'Apparent' thermal properties which model the 'effects' of these behaviours not the physical mechanisms.
- 'Effects' are different for variations in fire.
- EN 1995-1-2 has barriers to performance based design!

A MCM for softwood exposed to parametric design fires- Solution?

- König (2006) proposes that only the char layer conductivity properties are dependant upon rate of heating (i.e. 300-350+° C)
- Still working with 'effective/apparent' properties can we numerically calibrate char conductivity for different types of fire? In simple terms Γ and qtd distinguish realistic compartment fire behaviour from the standard curve. Find a relationship between Γ, qtd and λ for the heating phase of parametric fires (Hopkin, et al. 2011):

Temperature (°C)	Conductivity (W/m K)
20	0.12
200	0.15
350	0.07
500	$0.09k_{\lambda,\mathrm{mod}}$
800	$0.35k_{\lambda,\mathrm{mod}}$
1200	$1.50k_{\lambda,\mathrm{mod}}$

Temperature (°C)	Density ratio G	Cachim and Franssen moisture modified specific heat (J/kg K)
20	1+ω	(1210+4190ω)/G
99	1+ω	(1480+4190ω)/G
99	1+ω	(1480+114600ω)/G
120	1.00	(2120+95500 ω)/G
120	1.00	2120/G
200	1.00	2000/G

$$k_{\lambda,\mathrm{mod}} = k_{\Gamma,\mathrm{mod}} k_{qtd,\mathrm{mod}}$$

with $k_{\Gamma,\mathrm{mod}} = 1.5\Gamma^{-0.48}$, $k_{qtd,\mathrm{mod}} = \sqrt{\dfrac{q_{td}}{210}}$ *and* $\Gamma = \dfrac{(O/b)^2}{(0.04/1160)^2}$,

where ω is the moisture content of timber (%), O is an opening factor ($m^{0.5}$) and b is compartment thermal inertia ($J/m^2s^{0.5}K$).

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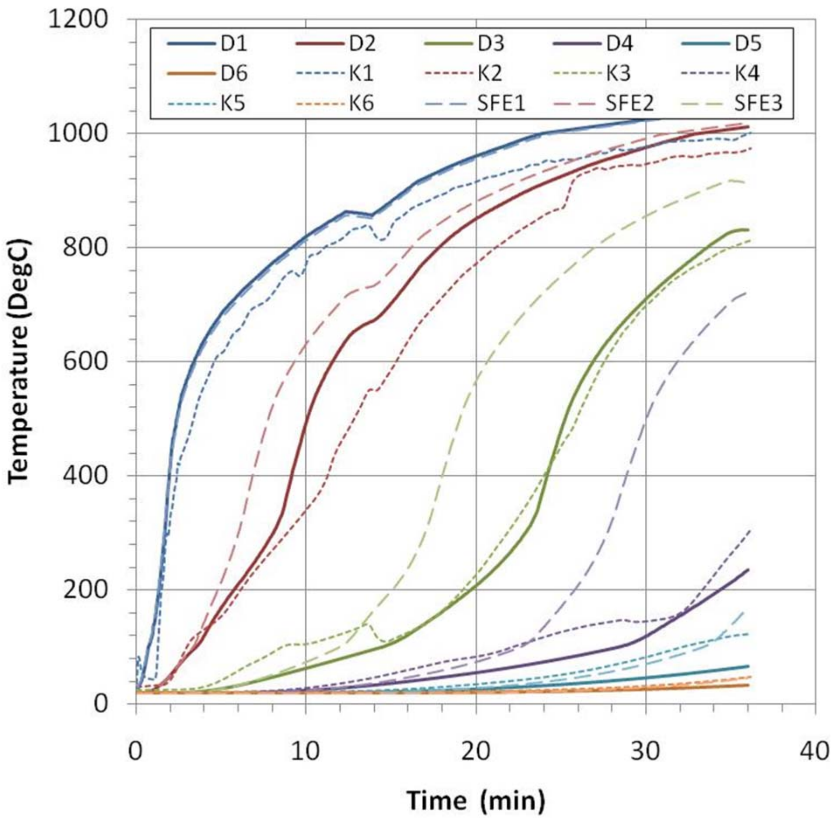
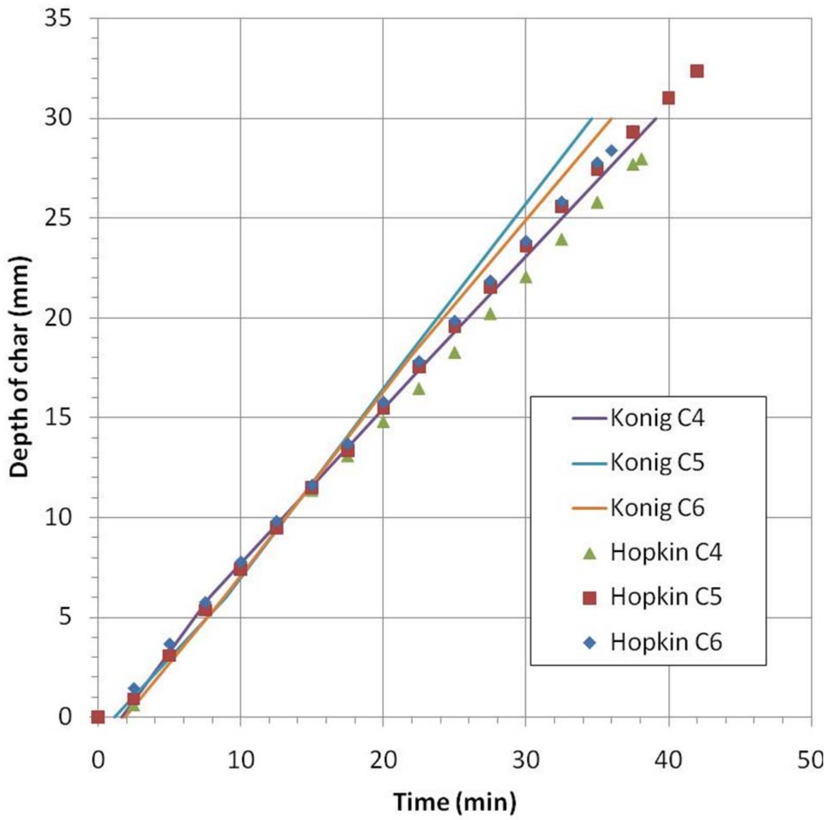
A MCM for softwood exposed to parametric design fires- Results

- Significantly improved correlation with experimental observations of timber exposed to parametric fires:





A MCM for softwood exposed to parametric design fires- Caveats/Critique

- It is not a true 'scientific' solution. Developed via numerical calibration. But neither is EN 1995-1-2!
- The proposed MCM only works for the heating phase of natural (or representations of) fires. Under predictions of charring depth and temperature development occur upon cooling. Why? Char oxidation and it appears thermal properties depend not only on heating rate and duration but also rate of cooling.
- Possible solution- phased transient analysis. Division of the heating and cooling phases. A pragmatic solution is presented in the proceedings for 'design' purposes.
- The way forward? Scientific robustness & complication vs. pragmatism & usability….Designers will always opt for the latter!

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