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UNPROTECTED STEEL IN MULTI-STOREY CAR PARKS

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INTRODUCTION

Visible steel structures are aesthetically appealing and cost effective. These advantages can often not be used because steel constructions must be protected for structural fire safety reasons. Due to numerous examinations no fire resistance of the support structure is required in Germany for open car parks. For the reason of high ventilation and low fire load densities the reduced fire resistance of unprotected steel is adequate (Fig. 1).

Thus, unprotected steel is used by several providers of multi-storey car parks in Germany during the last decade (Fig. 2). In some European countries, for example the Czech Republic, the fire resistance level R15 for open car parks is required. The main objective of the presented investigations is to check whether the steel/ composite construction fulfils this requirement.

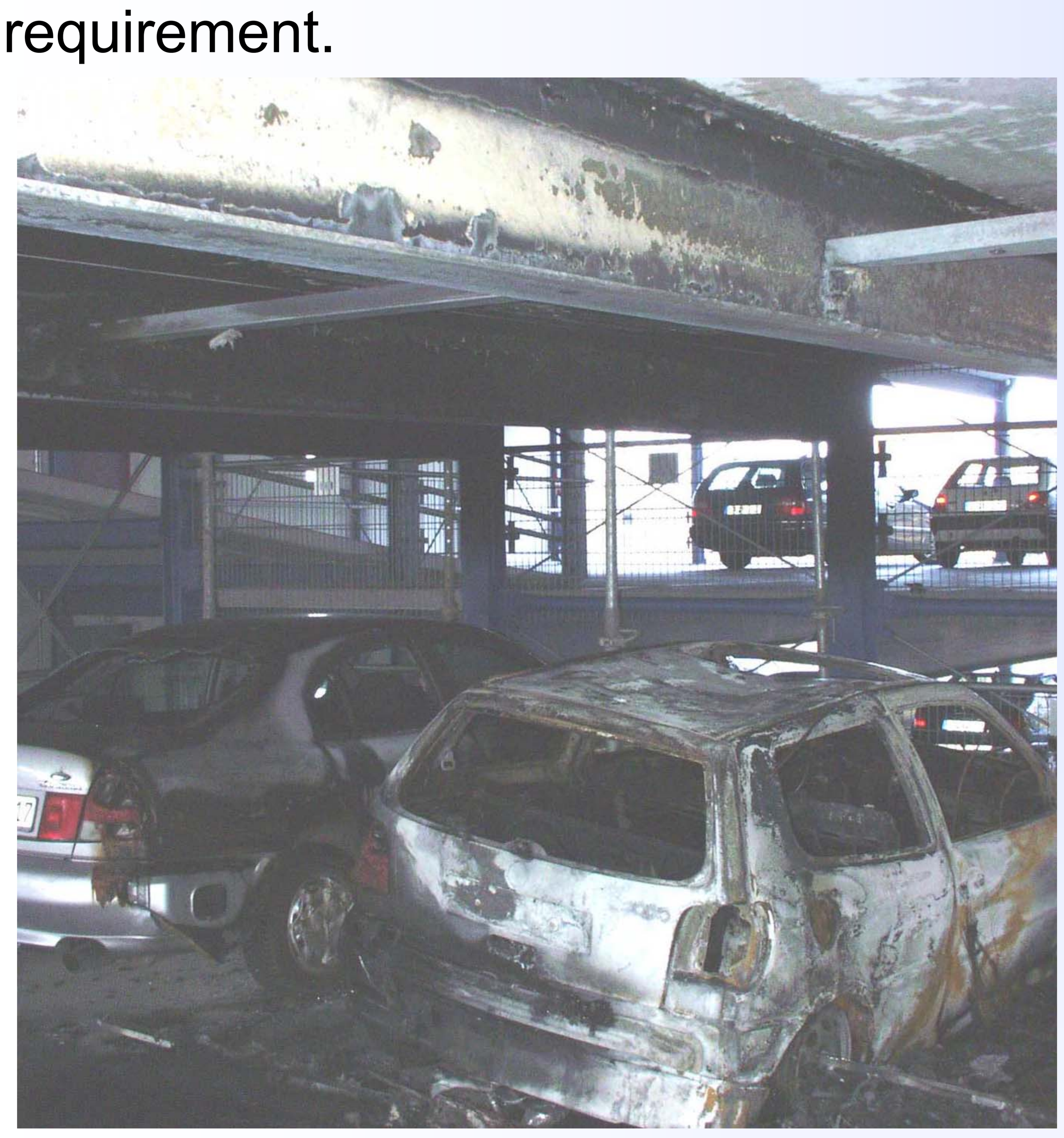

Fig.1: Cars and composite beam after fire in car park

METHODS

- Approach by Schaumann to calculate temperatures (Fig.4)
- Temperature calculation by incremental method of EC3 and EC4
- Resistance based calculation method of EC3 and EC4 (simple calculation method)
- Advanced calculation of fire resistance by BoFire

Fig. 2: Open multi-storey car park with unprotected steel (©GOLDBECK)

ANALYSED STRUCTURES

The study included two different composite beams and twelve types of columns belonging to the GOBACAR system by the company GOLDBECK. The members of the construction system and the applied loads were taken from a static analysis for a completed car park in Dresden. Selected members are shown in Fig. 3.

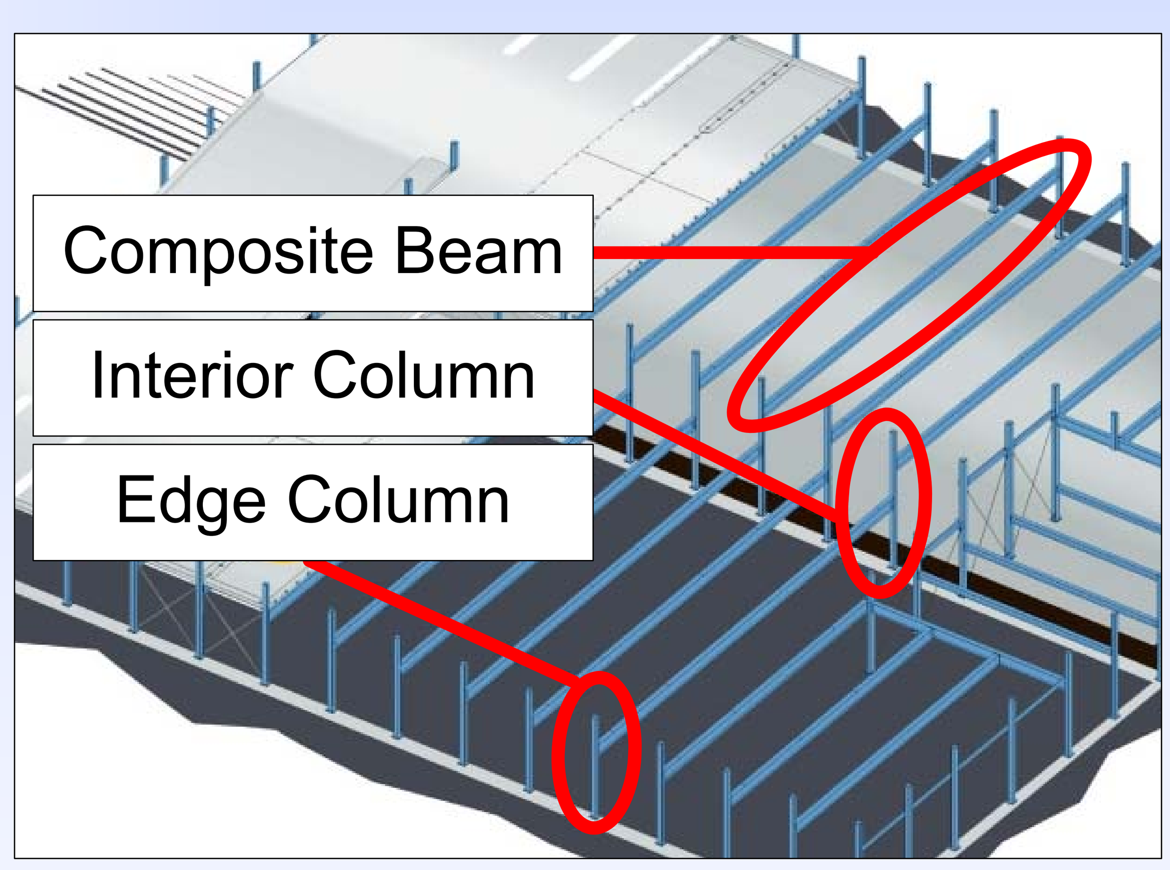

Fig. 3: Analysed members of car park (©GOLDBECK)

$\theta_{a,t}=\frac{c_1 \cdot c_2 + c_3 \cdot t^{c_4}}{c_2 + t^{c_4}}$		
$c_1=\theta_0=20°C$	$c_3=\frac{9875}{0.486+1.89\cdot\ln\left(k_{sh}\frac{A_m}{V}\right)}$	
$c_2=11890\cdot\left(k_{sh}\frac{A_m}{V}\right)^{-1.1}$	$c_4=1.253+0.071\cdot\ln\left(k_{sh}\frac{A_m}{V}\right)$	
$\left(A_m/V\right)$ [m^{-1}]	Area exposed to fire divided by volume	Min: 25 m^{-1} Max: 300 m^{-1}
t [min]	Time	Max: 30 min
$\Theta_{a,t}$ [°C]	Steel temperature	Max: 700°C

Fig. 4: Approximation of temperature increase in unprotected steel section

RESULTS

The calculation of the fire resistance time by simple calculation methods showed that it is possible to meet the fire resistance class R15 for composite and steel members. Therefore a minimum thickness of the steel parts or a maximum utilisation factor is necessary. Due to GOBACAR system is optimised for normal temperatures, the utilisation factor of most members is high. Thus the fire resistance class is not reached and the application of bigger steel sections is necessary for the use of unprotected steel in this case (overdesign).

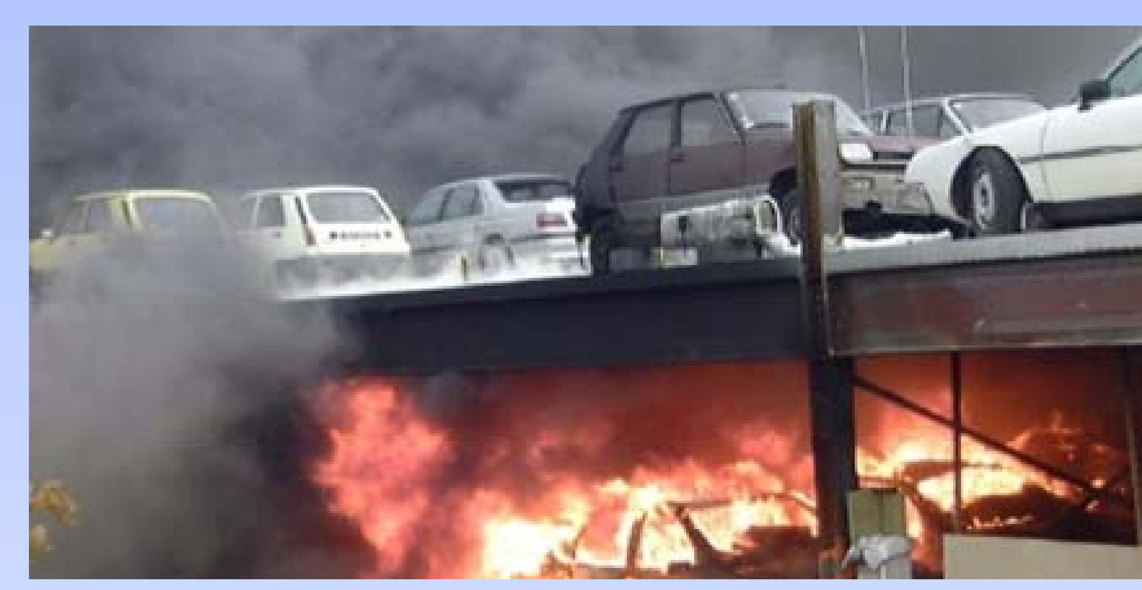

Fig. 4: Fire test in open car park in France

ADDITIONAL REMARK

The advanced calculation method gives conservative results compared to simple methods in this case. This is caused by the shadow factor k_{sh}, which reduces the calculated temperatures in the simple calculation method. The factor is not applicable to advanced calculation methods. Alternatively, the configuration factor may be applied for advanced calculation methods. This factor has to be determined experimentally.

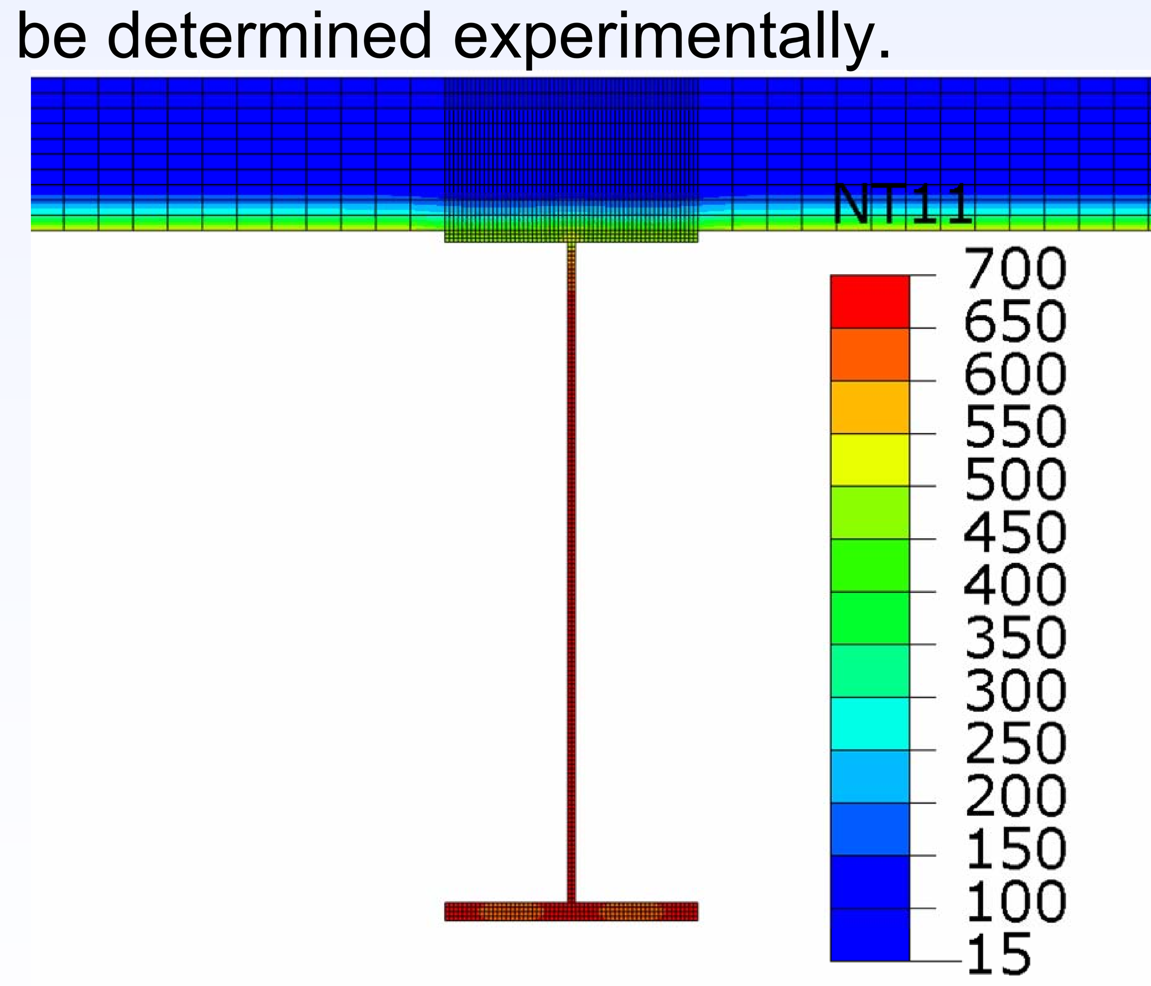

Fig. 5: Temperatures in composite beam after 15 min exposed to ISO-fire curve