APPENDIX: MATERIAL PROPERTIES AND SPECIFICS OF COLUMNS AND FURNACE

The values of the material properties used in this study are the same as those used in Reference 16 for the calculation of the fire resistance of concrete filled steel columns.

STEEL PROPERTIES

Stress-strain relations

$$f_s = \begin{cases} \dfrac{f(T, 0.001)}{0.001}\varepsilon_s & \text{for } \varepsilon_s \le \varepsilon_p \\ \dfrac{f(T, 0.001)}{0.001}\varepsilon_p + f(T, (\varepsilon_s - \varepsilon_p + 0.001)) - f(T, 0.001) & \text{for } \varepsilon_s > \varepsilon_p \end{cases} \quad (23)$$

where

$$\varepsilon_p = 4 \text{ x } 10_0^{-6} f_{y0} \quad (24)$$

$$f(T, \varepsilon_s) = (50 - 0.04T)\left[1 - \exp\left((-30 + 0.03T)\sqrt{\varepsilon_s}\right)\right] * 6.9 \quad (25)$$

Thermal capacity

$$\rho_s c_s = \begin{cases} (0.004T + 3.3) \times 10^6 & \text{for } 0 \le T \le 650°C \\ (0.068T - 38.3) \times 10^6 & \text{for } 650 < T \le 725°C \\ (-0.086T + 73.35) \times 10^6 & \text{for } 725 < T \le 800°C \\ 4.55 \times 10^6 & \text{for } T > 800°C \end{cases} \quad (26)$$

Thermal conductivity

$$k_s = \begin{cases} (-0.022T + 48) & \text{for } 0 \le T \le 900°C \\ 28.2 & \text{for } T > 900°C \end{cases} \quad (27)$$

Coefficient of thermal expansion

$$\alpha_s = \begin{cases} (0.004T + 12) \times 10^{-6} & \text{for } T < 1000°C \\ 16 * 10^{-6} & \text{for } T \ge 1000°C \end{cases} \quad (28)$$

CONCRETE PROPERTIES

Stress-strain relations

$$f_c = \begin{cases} f'_c\left[1 - \left(\dfrac{\varepsilon_{max} - \varepsilon_c}{\varepsilon_{max}}\right)^2\right] & \text{for } \varepsilon_c \le \varepsilon_{max} \\ f'_c\left[1 - \left(\dfrac{\varepsilon_c - \varepsilon_{max}}{3\varepsilon_{max}}\right)^2\right] & \text{for } \varepsilon_c > \varepsilon_{max} \end{cases} \quad (29)$$

where

$$\varepsilon_{max} = 0.0025 + (6.0T + 0.04T^2) \times 10^{-6} \quad (30)$$

$$f'_c = \begin{cases} f_{c0} & \text{if } T < 450°C \\ f_{c0}\left[2.011 - 2.353\left(\dfrac{T - 20}{1000}\right)\right] & \text{if } T \ge 450°C \end{cases} \quad (31)$$

Thermal capacity

$$\rho_c c_s = \begin{cases} (0.005T + 1.7) \times 10^6 & \text{for } 0 \le T \le 200°C \\ 2.7 \times 10^6 & \text{for } 200 < T \le 400°C \\ (0.013T - 2.5) \times 10^6 & \text{for } 400 < T \le 500°C \\ (-0.013T + 10.5) \times 10^6 & \text{for } 500 < T \le 600°C \\ 2.7 \times 10^6 & \text{for T} > 600°C \end{cases} \quad (32)$$

Thermal conductivity

$$k_c = \begin{cases} (-0.00085T + 1.9) & \text{for } 0 \le T \le 800°C \\ 1.22 & \text{for } T > 800°C \end{cases} \quad (33)$$

Coefficient of thermal expansion

$$\alpha_c = (0.008T + 6)x\ 10^{-6} \quad (34)$$

WATER PROPERTIES

Thermal capacity

$$\rho_w c_w = 4.2 \times 10^6 \quad (35)$$

Heat of vaporatisation

$$\lambda_w = 2.3 \times 10^6 \quad (36)$$

SPECIFICS OF COLUMNS AND FURNACE

$\varepsilon_f \varepsilon_s$ = 0.9 (37)

KL = effective length of columns: 2.0 m for fire resistance calculations (38)

ℓ = length of column that contributes to axial defor m ation: 3.5 m (39)

φ = concentration of moisture in concrete by volume: 0.10 (40)