TASEF technical information

Introduction to finite element theory

When calculating temperature in fire exposed structures non-linearities must be considered. The boundary conditions and the thermal properties vary significantly with temperature. Therefore numerical methods must be employed. The most general and powerful codes are based on the so called finite element method FEM.

Several general very powerful codes are commercially available. TASEF is a code specifically devoted to fire safety engineering problems with a number of features making it advantageous for that purpose.

Heat conduction equation

Tasef solves the heat conduction equation in plane two dimensions

$$\frac{\partial}{\partial x}\left(k \cdot \frac{dT}{dx}\right) + \frac{\partial}{\partial y}\left(k \cdot \frac{dT}{dy}\right) = c \cdot \rho \cdot \frac{dT}{dt} = \frac{de}{dt}$$

where k is conductivity and T temperature. The right hand side of the equation expresses the rate of heat change which can be expressed in terms of specific heat c and density ρ or alternative as a change of enthalpy e. Also axial symmetric three dimensions problems may be solved.

Radiation and convection boundary conditions

Heat is transferred by radiation and convection to fire exposed surfaces. These two processes are independent. Thus the boundary condition, i.e. the heat flux to a surface $\dot{q}''_{tot}$, can be written as

$$\dot{q}''_{tot} = \varepsilon \cdot \sigma(T_r^4 - T_s^4) + h_c(T_g - T_s)$$

where T_r and T_g are the radiation and gas temperatures, respectively, which can be input independently as functions of time. ε is the exposed surface emissivity, σ the Stefan-Boltzmann constant and h_c the convection heat transfer coefficient.

When simulating furnace tests radiation and gas temperatures are in general assumed equal. That is, however, not the case when analysing exposures from façade fires, local fires, or any pre-flashover conditions. Then radiation and gas temperatures must be specified individually which is possible in TASEF.

Voids and shadow effects

Many structural assemblies contain voids and enclosures. In these heat is transferred by radiation and convection which must be considered particularly at elevated temperatures. TASEF has a very accurate method of computing heat transfer between the surfaces surrounding enclosures which may be of different materials. A special case of using this ability is when considering reduced thermal exposure, so called shadowing effects, as introduced in Eurocode.

Thermal properties of materials

The thermal conductivity of materials is input dependent on temperature. The specific heat capacity is input in TASEF as the specific heat content (enthalpy) dependent on temperature.

This is computationally advantageous when analysing materials contain moisture which has a significant effect on temperatures exceeding the boiling point of water.

Explicit method solution

TASEF uses an explicit solution technique which makes it computation times extremely short, generally in the order of a few seconds.

Libraries

To facilitate input thermal properties of steel, concrete and timber as given in Eurocodes are imbedded in TASEFplus as well as standard fire curves like ISO 834, EN 1363-1, ASTM E-119, the hydro-carbon curve as well as parametric fire curves according to Eurocode.