F8 – TEMPERATURE DEPENDENT MATERIAL PROPERTIES

Introduction

For thermal simulations of constructions subjected to fire conditions, the thermal conductivity, the specific heat and the density of materials often need to be defined as temperature-dependent properties. A comprehensive database of temperature-dependent material characteristics, suitable for use in the BISTRA and VOLTRA programs, is available in the Physibel Toolbox.

Temperature dependent thermal properties

The database contains temperature-dependent thermal properties for a variety of materials. Most material data originate from the Eurocodes, supplemented with values from academic literature and commercial sources. The source of each material is shown directly beneath its name.

Within the Toolbox material database, users can generate .FLA and .FCE files, which define temperature-dependent thermal conductivity and temperature-dependent specific heat, respectively. These files can then be imported and used in the Physibel programs BISTRA and VOLTRA.

Important remarks

- For some materials, the density also varies with temperature. However, in the Physibel software the density is treated as a constant. Since the transient heat transfer equations only use the product of density and specific heat (ρ x c), the effect of temperature-dependent density can be accounted for by incorporating the density variation into the temperature-dependent specific heat.

  For this reason, if the density of a material changes with temperature, the user must download the .FCE file containing the modified specific heat values (c') in which the density variation has already been taken into account. In the Physibel software, the user should then simply enter the density of the material at 20 °C as the constant density value.

- In the Eurocodes, $\rho(T)/\rho(20°C)$ is provided for materials such as gypsum plaster, fibreboard, timber, and mineral wool. However, the Eurocode includes multiple values for the density at 20°C for some material classes. In that case, the library, gives 1 example function for temperature dependent density (based on the minimum required value for the material in the Eurocode). Because of this, it is crucial that the user adjust both the density and the resulting c' (modified specific heat) values based on the actual density at 20 °C of the material used in their project.

After adjusting the density-dependent values, users can enter the updated thermal property data into the Custom Material section of the Toolbox. From there, they can download the corresponding .FLA and .FCE files that reflect their revised material properties.

- For stone wool (Eurocode 5), the thermal conductivity values above 400 °C also depend on the density at 20 °C. In the Toolbox, the data provided correspond to the minimum required density specified for this material.

  If a user needs thermal conductivity values for a different density, they should consult Eurocode 5:2025, Clause 8.5.4, where the relationship between density and thermal conductivity for mineral wool insulation is defined.

Emissivity Values

The table below shows the emissivity values of the materials listed in the Eurocodes.

Material name	**Emissivity value ε (-)**
Steel	0.7
Hot-dip galvanized steel (T ≤ 500°C)	0.35
Hot-dip galvanized steel (T > 500°C)	0.7
Stainless steel	0.4
Aluminium clear	0.3
Aluminium painted and covered	0.7
Concrete	0.7
Gypsum	0.8
Timber	0.8
Mineral wool	0.8