ANALELE UNIVERSITĂȚII
"EFTIMIE MURGU" REȘIȚA
ANUL XVII, NR. 1, 2010, ISSN 1453 - 7397

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Behavior at High Temperatures of Steel Used for Constructions (Reactions to Fire)

The purpose of the present paper is to determine the response of main elements and resistance structures to extreme circumstances, specifically to action of conflagration, considering the temperature distribution inside structure's elements, materials characteristics – steel for this case – following the determination of thermo-mechanic response of main elements and resistance structures.

Keywords: *structure, resistance, temperature, steel*

1. General concepts

In the developments made in classical thermo-elasticity, thermo-physical and thermo-mechanical properties of materials are generally considered uniform. This assumption is justified by the fact that the effects of climate changes and temperature variations are studied.

This point of view no longer holds in situations in which is studied the behavior of main elements and main structures at high temperatures due to conflagrations. To approach this complex physical phenomenon by calculation, in addition to knowing a large amount of data and methods, it is necessary to know evolution of thermo-physical, thermo-elastic and thermo-mechanic properties of materials at temperature increase. Like any measures that depend on the nature of material, these properties can also be determined only experimentally.

The purpose of present paper is to determine the response of a resistance structure under fire action, but this primarily involves knowing material characteristics, in this case of steel, at high temperatures.

These parameters interfere in first step in calculus of temperature distribution inside structure's parts which, in turn, is the underlying for determination of thermo-mechanical response of resistance parts or structures.

Hence, the thermo-physic properties: thermal conductivity, λ, specific heat, c, and density, ρ, interfere with the heat conduction equation and thermal expansion coefficient, α_1, interferes with evaluation of thermo-mechanic response of structure.

Estimation of structures considering exceptional actions – such as the ones caused by high temperatures engendered by conflagrations – requires knowing a complex process, time progressive, due to parameter changes, used for calculations, such as thermal and mechanical characteristics of materials.

2. Steel's thermo-physical properties at high temperatures (conflagration).

a) Thermal conductivity λ

Thermal conductivity coefficient of steel is higher compared to other materials used in constructions. For example, at temperature of $20^\circ C$ its value is $50 W / m \cdot k$, while the value for concrete is $1.8 W / m \cdot k$.

Experimental results regarding fluctuation of thermal conductivity with temperature, indicating the conductivity's dependence on carbon's content and its decrease with increase of temperature.

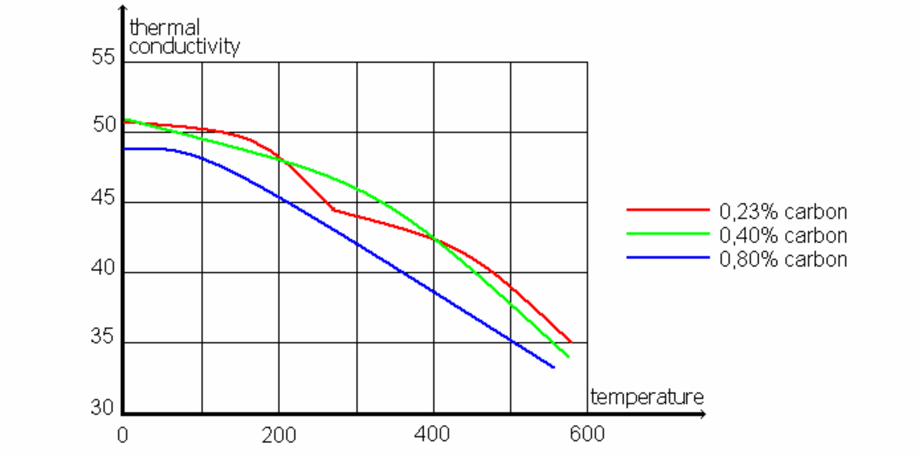

Figure 1. Steel thermal conductivity's fluctuation with temperature

Figure 1 shows the experimental results obtained in [1] and indicates the temperature's influence upon thermal conductivity of steel for three different carbon percentages.

It can be noticed that once the carbon percentage rises the conductivity λ lowers really fast.

b) Specific heat (Specific heat capacity) – c

The experimental results obtained in [2] and [3] indicate that whit rising of temperature the specific heat of steel rises as well. In figure 1 it is shown fluctuation of steel's specific heat for the same three percentages used in figure 1 for carbon concentration. By examining the curves it can be pointed out that the values for specific heat are being very little influenced by the carbon concentration.

c) Density - ρ_0

Experimental results point to slight fluctuations of steel's specific weight with temperature, therefore this variation is not taken into consideration in calculus. Usually value of density is considered $\rho_0 = 7850 kg/m^3$.

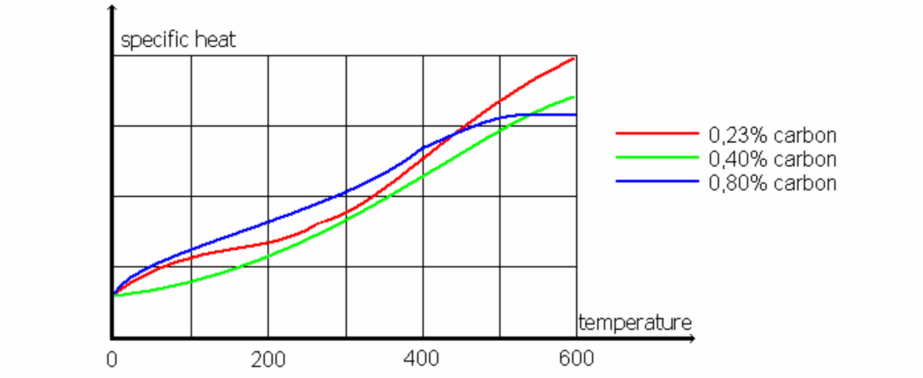

Figure 2. Fluctuation of steel's specific heat with temperature

d) Thermal diffusion - d_0

$$d_0 = \frac{\lambda_0}{c_0 \cdot \rho_0}, \quad (1)$$

Variation of this parameter with temperature can be obtained based on previous results. It can be noticed that:

- Thermal diffusion decreases with the increase of temperature (fig. 3)
- Thermal diffusion of steel exceeds by far other construction material's thermal diffusion (ten times higher than the one of concrete), that being one of the reasons which for the steel parts and concrete ones have a highly different behaviour in case of conflagration

e) Thermal expansion coefficient - α_1

Steel's thermal expansion coefficient has the value of $\alpha_1 = 10 \cdot 10^{-6} / ^o C$ for a $20^o C$ temperature and it is practically constant regardless carbon density.

The coefficient α_1 increases with temperature, hence it can be observed that:

- Results dissipation is reduced;
- The influence of carbon's density is neglectable.

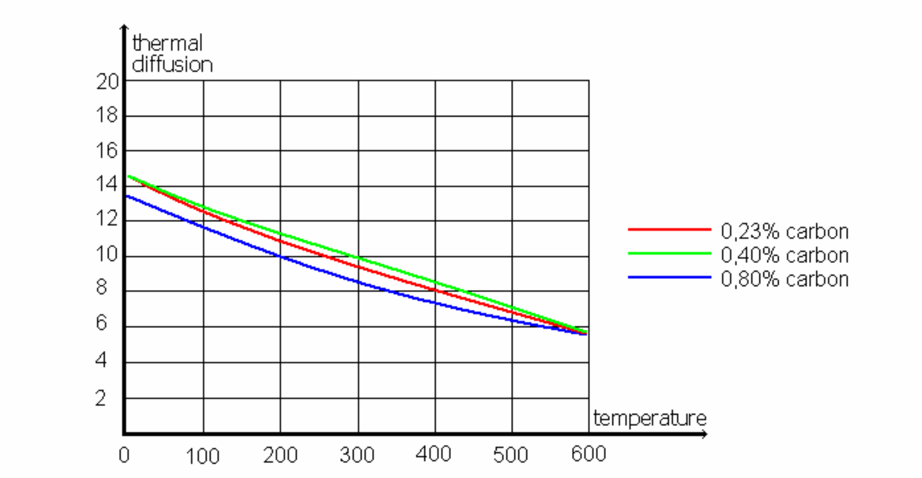

Figure 3. Fluctuation of steel's thermal diffusion with temperature

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