

# **[COST] Action TU0904 STSM: Thermo-mechanical analysis of steel columns using different constitutive laws**

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## **Scientific report**

Application of advanced calculation models in fire analyses requires special attention by the designer to computing the software capacity and reliability and the type of finite element adopted for the structural model.

Obviously the type of finite element (FE) used in the analyses, as well as the modeling of the thermo-mechanical properties, influence the analyses results.

During the period lasted in Sheffield Domenico Sannino has developed a benchmark study between three software, in order to evaluate the differences in the results and also the influence of some parameters on the same results. The software used for the analyses are Vulcan (in particular these analyses was already developed by Marios Alexandrou, a student at the University of Sheffield collaborating with Prof. Burgess), Safir and Strand7. The first two are specific purpose software for fire analyses, so they can correctly model the constitutive law for steel at high temperature, according to Eurocode 3. Instead Strand7 is a general purpose software. It allows more possibilities than the others to simulate different type of analyses, such as seismic ones, also it allows more possibilities to use different finite elements in respect of one-dimensional type, such as two or three dimensional finite elements. Nevertheless in case of fire analyses Strand7 is characterized by some approximation in the modeling. In particular it only allows to model a simplified constitutive law for steel at high temperature (elastic-plastic), so neglecting the parabolic branch between the proportionality limit and the yield stress.

The use of this type of simplified constitutive law does not effectively affect the results in terms of time collapse when the structures or substructures analyzed are characterized by collapse due to attainment of maximum tension for the material. Instead, for analyses in which the buckling phenomena represent the dominant collapse mode, this simplified constitutive law can significantly, sometimes deeply, affect the results, both in terms of time to collapse and displacement behaviour. This is because the buckling phenomenon can often happen when the material stress is

moving over the parabolic branch of the constitutive law. This is clearly more justifiable as the load ratio increases.

The STSM's activities started in August 5th and they ended in August the 15th. The goal of the STSM was to investigate and to demonstrate the importance of an according code modeling of constitutive law for steel at high temperature, especially in buckling analyses. For this reason, the analyses focused on a simply supported column subjected to axial load and fire. In particular the fire was simulated by a constant distribution of temperature in the cross section of the member. The temperature used in the analyses is obtained from the application of the formula for unprotected steel member proposed in the simplified calculations model of Eurocode 3 (see Eurocode 3-1-2 point 4.2.5.1), while the axial load is supposed to be constant during the fire.

The varying parameters are the slenderness of the member and the load ratio, in particular it was evaluated the variation of the critical temperature for the member by varying this two parameters.

In the first phase the analyses were carried out through Safir and Strand7, to validate and extend the results obtained through Vulcan.

In the second phase, in order to interpret the reason of the differences found in the first phase, the results obtained by applying the simplified method for the evaluation of the resistance of a simply compressed member in case of fire were added to the previous results. This allowed us to obtain a sure criterion for the evaluation of the numerical results.

The results of the analyses carried out during the STSM's period will be presented in a benchmark study during the next Cost meeting to be held in Aveiro in October 2013. In the remaining time the applicant will be engaged in trying to add other software results to the existing ones, in order to extend and to improve the results of the benchmark.



Domenico Sannino