The Use of Adiabatic Surface Temperature as a Method for Temperature Calculations in Structural Elements

Joakim Sandström[a], Ulf Wickström[b], Milan Veljkovic[c]

[a] Luleå university of technology/Brandskyddslaget AB, Karlstad, Sweden
[b] Luleå university of technology/Swedish National Reseach and Testing Institute, Borås, Sweden
[c] Luleå university of technology

This project is part of a larger project trying to develop a method for risk classification of buildings with regards to brittle failure. Among the different areas of research in this project there is a need to find ways to use results from computer fluid dynamic calculations (CFD) in the structural analysis.

An earlier study by Ulf Wickström att SP - Swedish National Reseach and Testing Institute presented the connection between the theoretical adiabatic surface temperature, T_{AST} and the temperature traditionally referred to as the fire temperature, T_f. By using this relation it was possible to create a thermometer, the plate thermometer, that consisted of a thin steel plate with insulated backing that with a small delay assumes an adiabatic temperature. The use of the plate thermometer in furnace testing made the testing result harmoniate in a better way with the com-parative calculations.

Another study by Wickström compared thermal calculations using the results from the plate thermometers surrounding the structural element to the measured temperatures with very good results.

In thermal calculations due to fire exposure there are three components, first the fire temperature, second the heat flux and third the thermal response. The fire temperature is a representation of the fire surrounding the beam and can be derived knowing the heat flux and thermal response thus creating a representaion of the fire surrounding the structural element.

Most fire simulations takes much time in consideration. Therefore it would be good to be able to use the results from one simulation on different structural elements. T_{AST} can be used as this.

In the latest version of the CFD-code FDS the Adiabatic Surface temperature was incorporated as an output data and enabled further study of T_{AST} as a fire representation.

By assuming that T_{AST} can be used as input in thermal calculations and that T_{AST} from a CFD-calculation can be seen as a representation of the surrounding fire temperature from one simulation would be possible to use on any, roughly similar structural element.

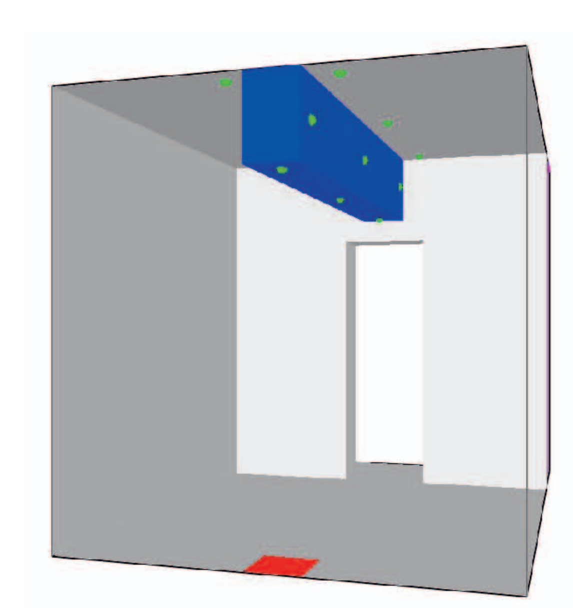


Figure 1 The model set up in FDS. Grey walls of concrete, blue box represents the structural element, the red plate represents the heat source and the green points represents the reference point in which the adiabatic surface temperature was calculated.

Two FDS calculations were performed with similar set up but with different sized structural elements. The model space consisted of a room of dimensions 1.6 m x 1.6 m with an opening of 1.2 m x 0.8 m. A heat source with constant effect of 500 kW was placed in the far end of the room (see Fig. 1). The different beams used were of dimensions 200 mm x 300 mm x 9.5 mm and 100 mm x 200 mm x 10.5 mm respectively. Two thermal calculations were performed on one beam using T_{AST} as input from each of the two FDS calculations (see Fig. 2).

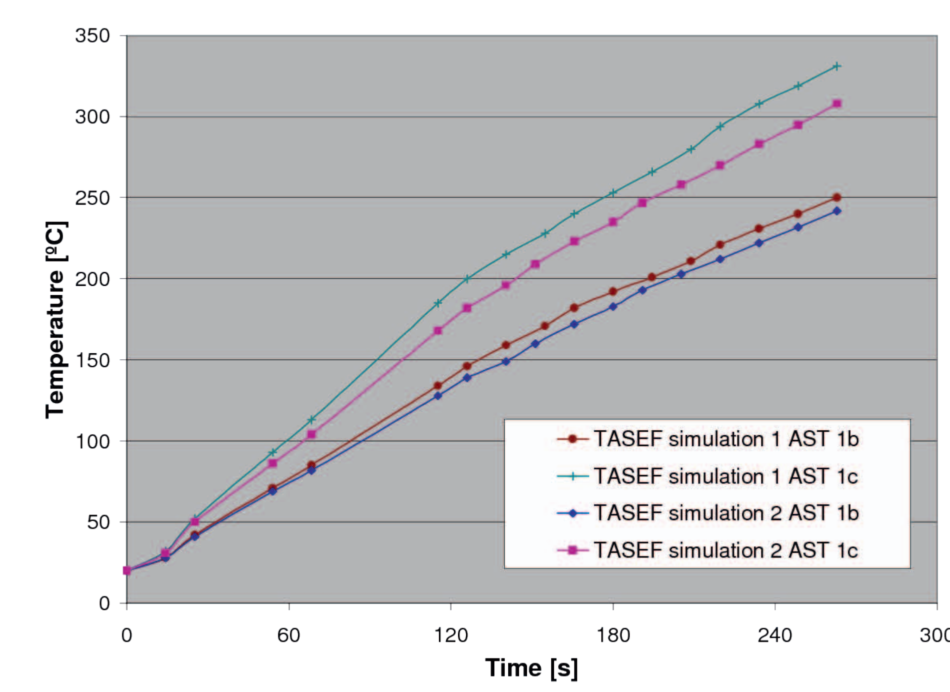


Figure 2 Comparison of thermal calculations performed on the beam of dimensions 200 mm x 300 mm x 9.5 mm with T_{AST} from each of the two simulations.

The results show that T_{AST} can be used as a representation of the fire environment calculated in FDS to be used on any similar structural element in identical scenarios.

The possibility to obtain T_{AST} from both testing, with plate thermometers, and CFD calculations, as made possible in FDS, creates a connection between simulation and furnace testing that both can benefit from (see Fig. 3).

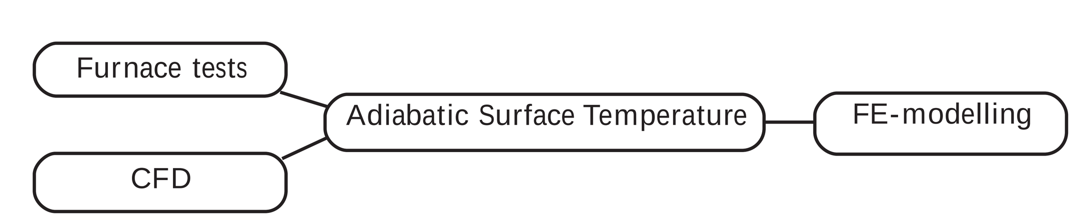
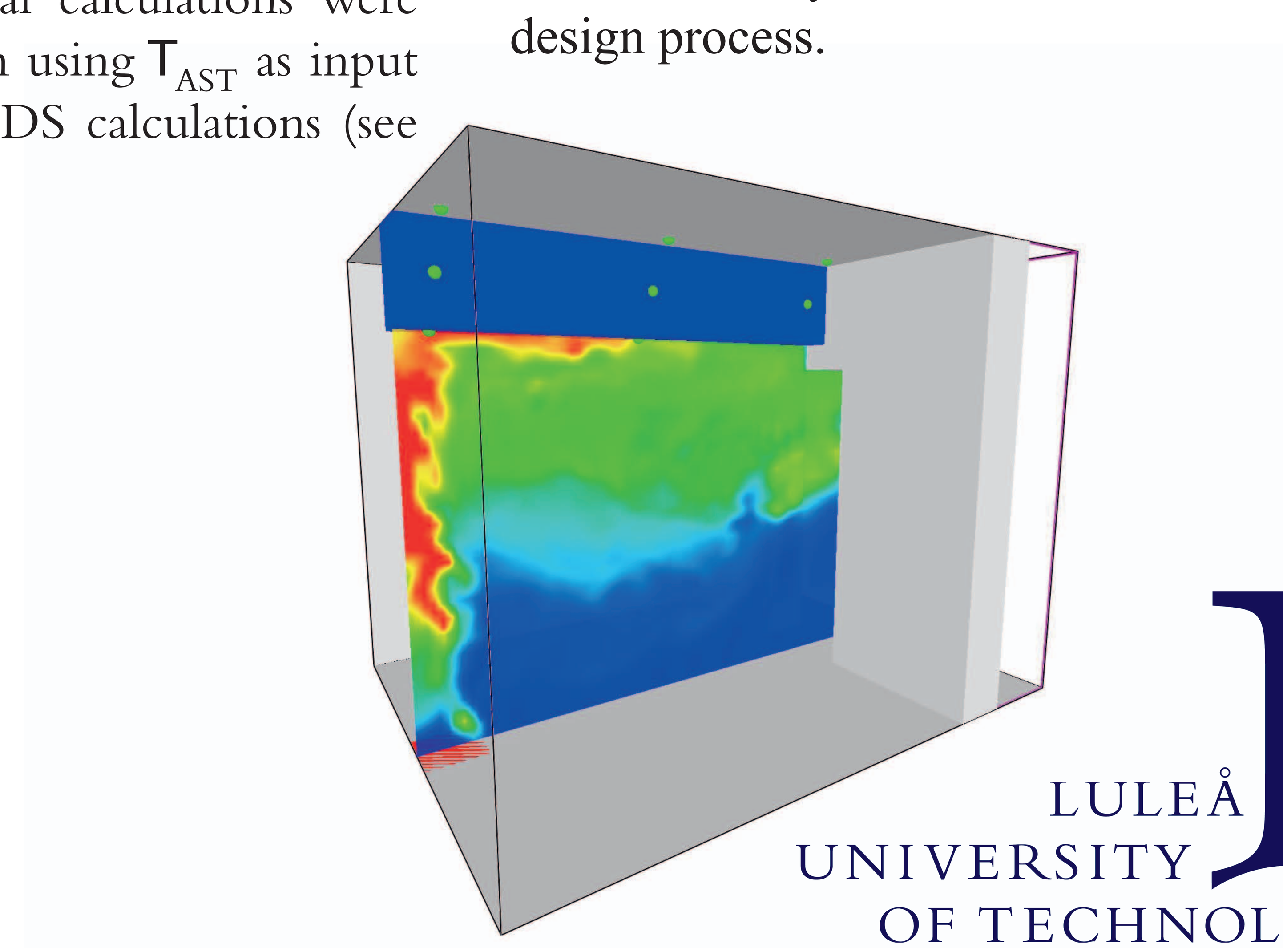


Figure 3 T_{AST} can be obtained from both furnace tests and CFD-calculations to be used in thermal FEM-calculations.

The further study of this concept at LTU will try to fully understand how T_{AST} can be used in the design process and in case studies. CFD can then become an even more powerful tool in the research trying to risk classify steel structures and in the design process.



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