# Computer Models
# For
# Fire and Smoke

*Model Name*: THELMA

*Version*: -----

*Classification*: Finite-element code

*Very Short Description*: Finite-element code for thermal analysis of building components in fire

*Modeler(s), Organization(s)*: Stephen Welch, Building Research Establishment (originally developed by James Kirby)

*User's Guide*: "THELMA - A finite-element package for solving two-dimensional thermal problems - User Guide", Kirby, J., Welch, S., 2000, FRS/BRE, 59 p.

*Technical References*: "THELMA - A finite-element program for modelling heat flow in solid materials containing small convex cavities, Kirby, J., Welch, S., FRS/BRE, 2000, 6 p.

*Validation References*: Morris, W.A., Kirby, J.A. (1997) "Computers and fire-safe structural design", presented at "Structures Congress XV", The Structural Engineering Institute of the American Society of Civil Engineering, 13-16 April 1997, Portland, Oregon

Kumar, S., Chitty, R. (1998) "Predicting thermal conditions in a steel compartment adjacent to a fire in an off-shore structure", in Proc. Symposium on Computational and Experimental Methods in Mechanical and Thermal Engineering, on occasion of 100th anniversary of the Laboratory of Machines and Machine Construction, Department of Mechanical and Thermal Engineering, University of Gent, Gent, Belgium, pp. 213-

Spearpoint, M. (1998) "A comparison of the predictions from the THELMA finite element model with a full-scale fire experiment", ENFP 621 - Project Report, University of Maryland, December 1998

Kumar, S., Chitty, R. (1999) "CFD study of thermal detection in a closed compartment subject to external fires", presented at the 6th International Symposium on Fire Safety Science, IAFSS, Poitiers, France, 5-9 July 1999

Welch, S. (2000) "Developing a model for thermal performance of masonry exposed to fire", First International Workshop on "Structures in Fire", Copenhagen, June 2000

*Availability*: Available direct from Stephen Welch, BRE

*Price*:

**DOS version** (lacking the recently-added features, e.g. moisture model/adaptive mesh)

Demo version is free
Full version is also free for research purposes, but requires HTBasic from the TransEra Corporation

**Windows version** (with recently added features)

Not available as interface development was done by external organisation

*Necessary Hardware*:

Intel architecture PC.
Original version runs under DOS only
Recent versions run under Windows (3.1/95, *not* NT).

*Computer Language*:

HTBasic by TransEra Corporation (http://www.htbasic.com/)
FORTRAN version exists, but is not interfaced

*Size*: c. 1.0MB (0.3MB zipped)

*Contact Information*:

Suresh Kumar (Dr)
Building Research Establishment, Garston,
Watford WD2 7JR, UK
Tel: +44 (0) 1923 66 4921
Fax: +44 (0) 1923 66 4910
Email: kumars@bre.co.uk

Alternate:
Stephen Welch
The University of Edinburgh
Faraday Building Rm 2.66
School of Engineering & Electronics

The King's Buildings, Mayfield Road
Edinburgh EH9 3JL
Tel: 0131 650 5734
Fax: 0131 650 6781
Email: S.Welch@ed.ac.uk

*Detailed Description*:

THELMA was developed at BRE for modelling the thermal response of construction materials to fire. It uses standard finite-element techniques to model the flow of heat through an arbitrary 2-D slice of a material, accommodating cavities as required, and describing boundary condition heat transfer via a convective heat transfer coefficient and a surface emissivity value. Temperature-dependent material properties are available and the latest version of the software includes a simple moisture model.

THELMA incorporates pre-processing facilities to allow the user to enter the geometry of the problem, generate a mesh and to assign material properties and boundary conditions. Standard fire exposure curves can be selected and material properties data is included for many common building materials. The built-in post-processor includes time-temperature and contour plotting facilities.

In early work, THELMA was validated against test data for steel, concrete and composite structures. Recently, the main area of interest has been masonry and a simple pre-processor for generation of the material properties datafiles has been written which calculates the effective temperature-dependent specific heat and thermal conductivity according to the initial moisture content in the material. In addition, an adaptive meshing feature was developed for the Windows version of the code.

The simple moisture model has been calibrated by comparison with through-thickness temperature data from 18 standard fire-resistance tests on masonry. It was found to be necessary to adopt significantly increased thermal conductivity values below the moisture vaporisation temperature of the material. This is not unreasonable, given the neglect of moisture *transfer* in this simple model, and the implicit assumption of a direct coupling of the moisture concentration and temperature.