Reliability of computer models in fire safety design

Computer-based models are in widespread use today as part of fire safety design. However, there is considerable concern about whether or not the use of such models may be leading to unacceptable options being adopted, writes Dr Alan Beard.

This concern covers all kinds of models, including computational fluid dynamics models. Concerns centre around the degree to which such models may or may not have the potential to represent the real world reasonably accurately and the ways in which such models may be used and results interpreted.

It is often stated in research articles that a model has been "validated" and a reader may think that this means that the model has somehow been "proven correct" and that use of the model will accurately represent the real world; however, this may be far from the case. Different users of a model may come up with very different results and this may be the case even for a model which has the potential to be valuable. Problems of this kind have been discussed in references [1,2] where three kinds of comparisons between theoretical predictions using deterministic models and experimental results have been identified. Brief descriptions of the types of comparisons are given here:

An a priori comparison is one in which the user has, effectively, not "seen" or used any results from an experiment being used for comparison.

A blind comparison is one in which the user has, effectively, not "seen" all the results from an experiment being used for comparison but some limited data from that experiment have been used as input, eg heat release rate or mass loss rate over time.

An open comparison is one in which data from an experiment being used for comparison have been seen and possibly used. The user is free to adjust input after initial comparisons.

Most comparisons between theory and experiment in the literature are of the "open" kind and very few are of the "blind" type. However, in real world design, the user is effectively in an a priori position with respect to a proposed facility or building. That is, a building or facility is being designed and a potential fire has not yet occurred in it. It is crucial, therefore, to conduct a priori comparisons with well instrumented experimental tests, but very few indeed have ever been performed.

Also, it is very important to carry out "round-robin" studies in which different model users carry out one or more simulations using their model, for a set fire test case specified by an independent party. The users would be given details of the set-up, but not experimental results. Results predicted by the different users would then be compared with experimental results for that test case. Such a study was conducted by the CIB (International Council for Research and Innovation in Building and Construction) during the late 1990s and the results showed considerable differences in results predicted by different users for the same specified case [3].

As a consequence of the poor showing of model use found in that study the report was not made widely available; because of this the results are not widely known.

A similar "round-robin" a priori study has just been carried out by Edinburgh University in collaboration with Strathclyde Fire Brigade, centred on the Dalmarnock fire tests. The results were presented at a meeting in Edinburgh in November 2007. In these tests a fire was started on a sofa in a two-bedroomed flat in Dalmarnock, Glasgow. The flat was in a high-rise block. Model users were given details of the arrangement, materials etc, but not the experimental results. They were invited to predict the time courses of variables such as heat release rate, temperature and smoke obscuration. The big question was, as with the CIB study: how would the predictions by model users compare with each other and with experimental results? Ten model user teams took part, eight using the same CFD model and two using a zone model. (There is no reason to think that the general nature of the results would have been different had these teams used a different CFD model or different zone model.)

"There was generally a wide scatter amongst the predictions by users and, also, predictions usually compared poorly with experimental results."

As a general rule the predictions were not at all good: there was generally a wide scatter amongst the predictions by users and, also, predictions usually compared poorly with experimental results.

For example, with regard to temperature, predictions tended to vary from about a 45 per cent over-prediction to about a 90 per cent under-prediction. (Sometimes a model prediction was close to the experimentally determined value for that variable, over part of the time range.)

The basic message was clear: a predicted result from a model cannot be assumed to be accurate; ie to reflect the real world. Further, consistency cannot be assumed; ie that a given model will consistently over-predict or consistently under-predict. Fuller details may be found in reference [4]. (These issues also relate to variability within experimental results, which is a cause of concern [2].)

Overall, the general conclusions appear to be similar to those which followed from the CIB study of the 1990s. Whether or not a model may be reliably used as part of fire safety decision-making depends not only upon the conceptual and numerical assumptions in the model itself but also upon how it is used and how the results are interpreted. Using models as part of decision-making may be

"Very recently a recommendation was made to the European Parliament that a framework be established to try to ensure the acceptable use of models as part of fire safety decision-making. It is to be hoped that effective action will be taken before much more time has elapsed."

dangerous. It should not be concluded, though, that it is impossible for models to be employed valuably as part of safety decision-making. It is necessary for a regulatory framework to be constructed which takes into account the potential for a model to be valuable, the methodology to be followed in using the model and the user, who must be knowledgeable.

A "knowledgeable user" must be capable of using an acceptable methodology to apply a particular model to a particular case in a comprehensive and exhaustive way, making all assumptions and procedures explicit, and interpreting results in a justifiable way.

These concerns go across the board and are not just pertinent to particular industries; they are discussed further in reference [5].

It is known that UK governmental departments, European organizations and the International Standards Organization (ISO) are concerned about these matters, yet, thus far, little has been done at a UK national or international level; although ISO has published an initial standard [6].

Very recently a recommendation was made to the European Parliament that a framework be established to try to ensure the acceptable use of models as part of fire safety decision-making [7]. It is to be hoped that effective action will be taken before much more time has elapsed.

References

1 Beard, A.N., 'On a priori, blind and open comparisons between theory and experiment', Fire Safety Journal, 35, pp 63-66, 2000

2 Beard, A.N., 'Problems with Using Models for Fire Safety', chapter 14 of The Handbook of Tunnel Fire Safety, eds. Alan Beard and Richard Carvel, Thomas Telford, London, 2005. (NB this chapter is general, not restricted to tunnels only.) ISBN 0-7277-3168-8

3 Hostikka, S., & Keski-Rahkonen, O., 'Results of CIB W14 Round Robin for Code Assessment'. Technical Research Centre of Finland, Espoo, Finland, 1998.

4 'The Dalmarnock Fire Tests: Experiments and Modelling', eds. G.Rein, C.Empis and R., Carvel; published by The School of Engineering, Edinburgh University, 2007, ISBN 978-0-9557497-0-4

5 Beard, A.N., 'Requirements for acceptable model use', Fire Safety Journal, 40, pp477-484, 2005

6ISO/BSI. 'Fire Safety Engineering-Part 3: Assessment and Verification of Mathematical Fire Models', BS ISO TR 13387-3:1999 ; London

7 Beard, A.N., 'Assessment of the Safety of Tunnels', October, 2007

THE AUTHOR

Dr Alan N. Beard, Civil Engineering Section, School of the Built Environment, Heriot-Watt University, Edinburgh, Scotland.

CONTROL LOGIC Spark detector

designed for dust collection systems to protect storage silos from the risk of fire.

Sparks fly at high speed.

They travel at a hundred kilometres per hour along the ducts of the dust collection system and reach the silo in less than three seconds

The CONTROL LOGIC SPARK DETECTOR is faster than the sparks themselves. It detects them with its highly sensitive infrared sensor, intercepts and extinguishes them in a flash. It needs no periodic inspection.

The CONTROL LOGIC system is designed for “total supervision”. It verifies that sparks have been extinguished, gives prompt warning of any malfunction and, if needed, cuts off the duct and stops the fan.

ISO 9001

20137 Milano - Via Ennio, 25 - Italy
Tel.: + 39 02 5410 0818 - Fax + 39 02 5410 0764
E-mail: controllogic@controllogic.it - Web: www.controllogic.it

CONTROL LOGIC s.r.l.

BETTER *TO KNOW* IT BEFORE

Eye is faster than nose.

In the event of live fire
the IR FLAME DETECTOR
responds immediately

CONTROL LOGIC IR FLAME DETECTOR

the fastest and most effective fire alarm device for industrial applications

**IR FLAME DETECTOR
RIV-601/FA
EXPLOSIONPROOF
ENCLOSURE**

For industrial applications indoors or outdoors where is a risk of explosion and where the explosionproof protection is required.
One detector can monitor a vast area and responds immediately to the fire, yet of small size.

Also for
RS485 two-wire serial line

**IR FLAME DETECTOR
RIV-601/F
WATERTIGHT
IP 65 ENCLOSURE**

For industrial applications indoors or outdoors where fire can spread out rapidly due to the presence of highly inflammable materials, and where vast premises need an optical detector with a great sensitivity and large field of view.

ISO 9001

20137 Milano - Via Ennio, 25 - Italy
Tel.: + 39 02 5410 0818 - Fax + 39 02 5410 0764
E-mail: controllogic@controllogic.it - Web: www.controllogic.it

CONTROL LOGIC s.r.l.