



INFORMATION SHEET: I-Beam Heat Transfer Challenge

Can you determine the heat transfer to a steel I-beam section?

You are invited to participate in an exercise involving the heating of a steel beam exposed to a pool fire.

The Objective

There is some concern that a number of structural fire design methodologies are overly conservative. In order to establish the validity of such concerns, it is necessary to determine the variability between *design* calculations and experimental measurements. Furthermore, if such methodologies are to be replaced by engineered solutions, it is also vital to assess our current engineering understanding of heat transfer (*i.e.* the crux of the problem), thus engineering *predictions* are also to be compared against experimental data. A simple, pertinent and highly repeatable experiment is used for the study, concerned only with the heat transfer process, and an extensive set of data is available for comparison.

The results of the study will be presented anonymously (no data will be directly linked to a participant or company), such that only individual participants will be able to identify their own submission amongst the data presented. Your contribution will be acknowledged in any publications that may result from this study, however if you wish that your name or company name not be openly acknowledged, such requests will be vehemently respected.

The study will therefore provide a general evaluation of the level of “conservatism” inherent in our “design” methodologies as well as an assessment of our current level of understanding of the heat transfer process. However, it should prove to be a particularly useful resource for participants, enabling them to re-evaluate their solutions for future design.

The Challenge

A steel I-section has been set-up under a large calorimetry hood and exposed to a given pool fire. Three main tests have been conducted, with an identical set-up, but for the height of the beam above the fuel surface.

The challenge is to determine the temperature evolution of the beam for any (or all) of the three tests. Participants are invited to submit entries based on a *design* approach as well as a *prediction* of the actual temperature evolution (*i.e.* the former using potentially ‘conservative’ assumption, the latter being a ‘realistic’ representation), where **both** pertain to the **specific fire scenario in question**.



In particular, participants are to determine the temperature evolution of the beam at mid-web height, at mid-span distance along the beam. Submissions will be compared against data obtained from thermocouple readings in the corresponding location. In order to facilitate comparison between submission and measured data, for any (or all) of the three tests please submit:

- i) A temperature-time function (cooling phase optional);
- ii) Temperature of the beam at mid-web, mid-span, 8 mins into the fire;
- iii) The area underneath the temperature-time curve described by (i);
- iv) A brief description of the assumptions (fire, heat transfer, *etc.*) and methodologies employed.

Please provide submissions relating to both a *design* approach and to an actual *prediction*, remembering to clearly indicate the corresponding approach taken for each submission. Also, if you or your company wish not to be named in any acknowledgements in resulting publications, please remember to accompany your submission with this request for omission.

The Scenario

The test set-up details are as follows:

Steel I-Section

Beam height: 200 mm
Flange width: 130 mm
Flange thickness: 9.6 mm
Web thickness: 6.4 mm
Length: 3 m

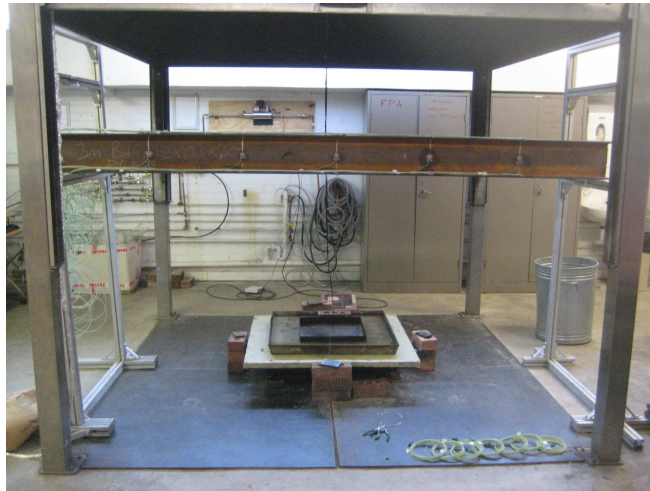
Pool Fire

400 mm by 400 mm square pan with 1.6 kg of heptane.

Test details

Test I: The beam (bottom flange) is positioned at 1.5 m above the pool fire;
Test II: The beam (bottom flange) is positioned at 1.0 m above the pool fire;
Test III: The beam (bottom flange) is positioned at 0.5 m above the pool fire.

In all cases the I-beam is centrally aligned above the fuel pan.



- Photo of the test set-up as per Test II -

Additional Information

The beam is rigged with thermocouples at 5 different cross-section locations along the beam, namely at mid-span and at 0.5 m and 1.0 m either side of mid-span. At each of these cross-sectional locations, 7 thermocouples are used to read the temperature evolution at the centre of the beam (mid-web), at each of the flange-web junctions and at each of the four flange tips (*i.e.* 35 beam-mounted thermocouples in total). Further thermocouples are used to measure the gas-phase temperature evolution approx. along the central flame axis, calorimetry is employed to determine the fire heat release rate (HRR) and heat flux measurements have been taken during a previous test, allowing for characterisation of the pool fire.

The beam is simply-supported (and somewhat secured at the top flange too) however there is no further restraint or load applied. This is an exercise in heat-transfer only.

The calorimetry hood extraction flow rate is: 1110 L/s.

Test III was conducted twice to allow an evaluation of experimental repeatability.

Participants are welcome to take the challenge further and provide submissions for the spatial-evolution of the temperature distribution throughout the beam (*i.e.* submit values pertaining to the location of each of the beam-mounted thermocouples), for comparison at a later date.

Submission

Please submit your entry to Cecilia Abecassis Empis at: c.abecassis-empis@ed.ac.uk

By: **28th October 2011**

Note: You may be contacted for further information regarding your assumptions and methodologies employed.