SUPSI

Behaviour of structural steels under fire in a wide range of strain rates

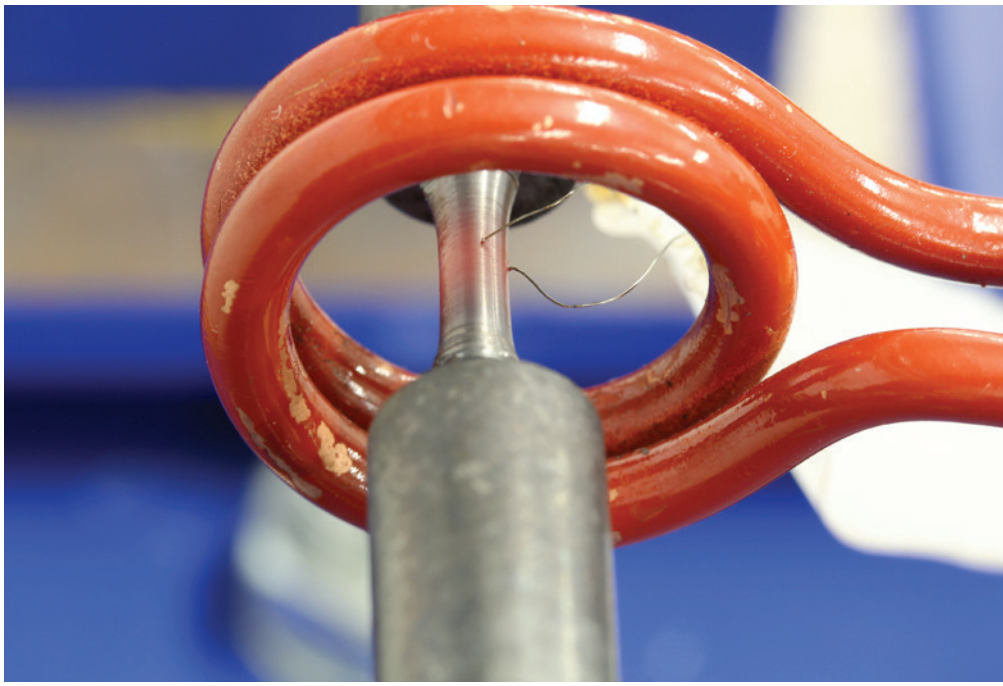
Axis 1 – Built environment

Interview with Daniele Forni, Project Director

Tell us briefly about the project, starting with the problem tackled.
New York, 11 September 2001. Airolo, 24 October 2001. We are unlikely to forget the dates that have affected the lives of many people as a result of most awful terrorist attack in history, which caused thousands of deaths, and of the accident in the St. Gotthard tunnel, which caused 11 deaths. These two events, both involving the presence of high temperatures, immediately made the international scientific community question how structures subjected to extreme actions, such as fires and explosions, could be made stronger and safer.

In order to make safer structures, a designer must understand the mechanical features of the material, particularly under extreme conditions, which are difficult to find under current legislative restrictions.
The research project entitled "*Behaviour of structural steels under fire in a wide range of strain rates*" was developed in order to meet this need, and made it possible to study the effect of these extreme actions on structural steels (S355, S690 and S960) and on reinforcement bars (AISI304, B500A, B500B), by means of a key series of tests combining high temperatures (from 20°C to 900°C), with various strain rates, from quasi-static (10^{-3} s^{-1}) to the most extreme dynamic conditions (1000 s^{-1}).

What initial results have been obtained?
The results of the tests have highlighted how mechanical properties are both sensitive to the deformation velocity, and affected by the temperature. It was particularly observed how dynamic conditions positively impact the mechanical performance of the materials, while high temperatures operate in the opposite direction, in the sense that the mechanical strength was observed to reduce significantly as the temperature increased.

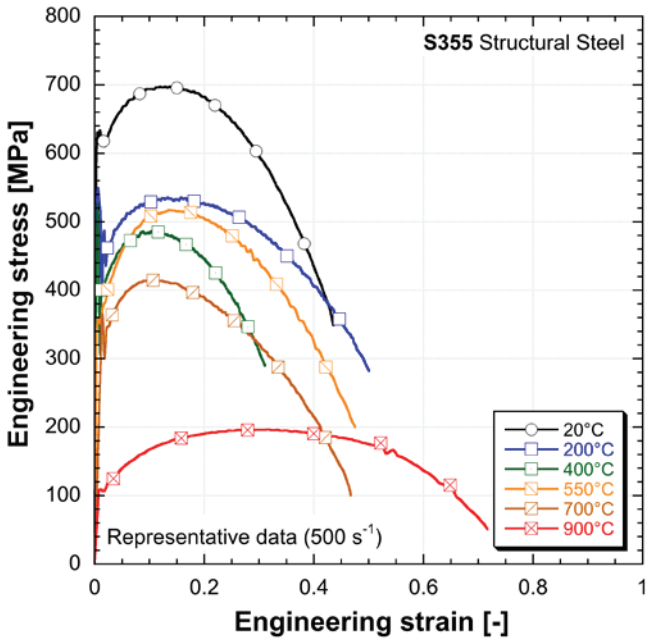


What are the strong points of the project? And the problems?
One of the project strong points is that it was possible to implement real data, that is to say data obtained experimentally, in a finite element code. A reliable multi-risk approach could therefore be proposed in order to calculate the combined effect of explosion and fire. This aspect was also the subject of my doctoral thesis. Moreover, a large part of the results has already been published in international journals, with the aim of disseminating the experimental data, and allowing designers to conduct reliable numerical simulations at the macro-structural level (*push-down analyses, alternate load path analyses, etc.*) in order to calculate structural strength under extreme conditions. One problem, on the other hand, is associated with the complexity of the analyses that can be executed: the specific competences required are not always available in design studios.

Do you remember anything interesting, amusing or unusual that occurred during the project?
When conducting the preliminary analyses of the experimental results, we realised that, under dynamic conditions, structural steel S355 behaved in a unique way, highlighted by the high-temperature tests. The results showed an unusual increase in the strength capacities with temperature increases from 400°C to 550°C (Diagram 1). These observations were then traced back to the phenomenon known as *dynamic strain ageing*, in other words, associated with the interaction between the nitrogen atoms and the dislocations.

Could other projects develop from this one?
Of course! In this project we examined only some of the many materials utilised in civil engineering. It would be interesting to conduct further study into the materials utilised in mechanical engineering, automotive engineering, aerospace engineering, etc.

Apart from you, who else was on the project team?
The project was conducted at the SUPSI DynaMat Laboratory, together with, apart from myself, Ezio Cadoni, Matteo Dotta, Gianmario Riganti and Nicoletta Tesio. Some of the tests were conducted by Prof. Mario Fontana's research group at the ETH Zürich Institute of Structural Engineering, and with the collaboration of Prof. Markus Knoblock from the Bochum University Institute of Steel, Lightweight and Composite Structures.



Project type: Behaviour of structural steels under fire in a wide range of strain rates
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