

Dr. Paweł A. Król, Ph.D., Civ.E.

Warsaw University of Technology, Faculty of Civil Engineering
Institute of Building Engineering, Metal Structures Section,
Al. Armii Ludowej 16, Civil Engineering Bldg., room 249,
00-637 Warszawa, POLAND
mobile: +48605378010
fax: +48228256532
e-mail: p.krol@il.pw.edu.pl

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Ing. Kamila Horová

The Grant Holder for COST Action TU0904
Department of Steel and Timber Structures
Czech Technical University in Prague
Thákurova 7, 166 29 Praha, Czech Republic
e-mail: kamila.horova@fsv.cvut.cz

Scientific Report from the Short Term Scientific Mission (STSM)

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My name is Paweł A. Król and I am an assistant professor at the Faculty of Civil Engineering, Warsaw University of Technology in Poland. Starting from 2010 I've also served as an expert of COST Action network TU0904 in domain Transport and Urban Development. I've been acting within the WG2 – Structural Safety working group, under supervision of Prof. Lesław Kwaśniewski – the chairman.

As I'm not only the scientist but also a certified structural engineer and designer, whose range of expertise is related mainly to steel structures – the behaviour of steel structures subjected to fire conditions is the main area not only of my scientific but also professional interests. I'm interesting in finding or developing some simple but effective solutions which would enable “first-line” engineers to assess in a relatively precise way the fire safety of real structures without the necessity of any sophisticated numerical tools application.

The topic of this Short Term Scientific Mission, established as: **“Assessment methods of steel beams (or columns) behaviour under fire conditions”** is closely related to the area of my scientific interests, performed research activities and may be treated as part of the wider study program, that I plan to be realised in future.

In time period from December 3rd to December 15th, 2013 I participated in the Short Term Scientific Mission at University of Ulster, Fire Safety Engineering Research and Technology Centre (FireSERT), School of the Built Environment, located at Jordanstown campus. Prof. Faris Ali, highly recognized specialist in the area, Professor of Structural Engineering and Editor-in-Chief of **“Journal of Structural Fire Engineering”** has agreed to host me and looked after me during all my stay in the UK.

My first day at FireSERT was mostly spent on some organizational and orientation issues. I was presented to the other staff members and the group of PhD students working under their supervision, and had some short chats with all of them. After my short self-presentation all of them also presented to me their areas of research and the work of their PhD students. As I found

out, the FireSERT combines a multi-disciplinary team of scientists, engineers and psychologists in a laboratory facility that is unique not only in Northern Ireland but also within the whole UK and European university sector. The four core areas of the institute activity are: - fire dynamics and materials, - structural fire engineering, - fire protection, and – human behaviour in fire.

After the meeting with academic staff, Professor F. Ali showed me the university library, has introduced me to the university IT system enabling the unlimited access to all the university facilities, resources and portals and presented to me how to operate with the system.

During the next day, two project engineers – Mr Maurice McKee and Mr Krzysztof Kowalski presented to me some laboratory facilities and majority of specialized equipment, collected in the lab. The facilities developed for undertaking research in this four key areas mentioned before are exceptional, a 600m² burn hall allows full-scale fire research to be undertaken. A 20 MW facility, a large-scale combination wall and floor furnace (3.0mx3.0mx4.0m long), intermediate and small size furnaces facilitate investigations over a wide range of scales. These facilities are complemented by a well-equipped fire dynamics and chemistry laboratory furnished with TGA/FTIR/DSC/MS and two cone calorimeters, one standard and one having a controlled oxidizer atmosphere. In addition to the experimental laboratories, extensive dedicated computer facilities are available for fire modelling, using CFD. A specific set of laboratories are also available for the investigation of human behaviour in fire, allowing fundamental work to be undertaken on human responses to fire and evacuation simulations.

A visit to the lab has made a big impression on me, especially that due to the courtesy of hosts I had the opportunity to participate in some fire tests carried out for the research project entitled **“Temperature assessment of a vertical steel member subjected to localised fire”**, currently realized in FireSERT. The project leader is Prof. Ali Nadjai.

The main objective of this project is to provide designers with scientific evidence, put in design models and, in the future, in the regulations (Eurocodes) that will allow them to design steel columns subjected to localised fires such as those which may arise, for example, in car parks. In fact, at the time being, such evidence, models and regulations exist for beam located under the ceiling, but nothing is available for columns, and this situation may lead to unnecessary and excessive thermal insulation that jeopardizes the competitiveness of whole steel projects.

Finally, together with prof. Faris Ali we both agreed that during this short visit I would focus my attention on issues related only to the assessment of columns behaviour, since this range better corresponded to research projects carried out currently and in the recent past in the FireSERT.

Over the next few days prof. Faris Ali presented me the results of experiments and numerical analyses conducted by him and his team within the research project entitled **“Behaviour of axially restrained steel columns with elliptical sections subjected to severe fire”**, that was finished with success in February this year.

Elliptical structural steel hollow sections represent a recent addition to the range of steel sections available to structural engineers. However, despite the extensive interest in their use on the basis of both architectural attraction and structural efficiency, a complete absence of fire resistance design guidance is restraining applications. The study involved investigating steel hollow and concrete filled elliptical steel sections subjected to severe fire scenarios. Some design rules was developed taking into account the fire engineer, with careful consideration given to finding the right balance between accuracy of result and ease of calculation methods.

Prof. F. Ali made available to me the paper copies of two recent publications of his co-authorship, devoted to assessment issues of resistance of steel columns resistance subjected to elevated temperatures:

- Kwaśniewski L., Ali F., Balcerzak M. (2013): *Coupled Structural-thermal Calculations for Restrained Steel Columns in Fire*, Journal of Structural Fire Engineering, 4 (1). pp. 59-70.
- Ali F., Jeffers A., Goodfellow N., Nadjai A., Sculltion T., Gardner, J. (2012): *Performance of Axially Restrained Hollow and Concrete Filled Oval Steel Columns Subjected to Hydrocarbon Fire*, Journal of Structural Fire Engineering, 3 (2). pp. 181-198.

The latter one contained a summary and the main concluding remarks from the realised research project.

The next and the last days of my short visit to the University of Ulster I spent in the reading room of the university library, looking through books and journals (both in paper and electronic copies) in and making notes. I lacked the time to even riffle some books or journals, of which the vast majority, issued in English, are not available in the library resources of any technical university in Poland.

This short visit to University of Ulster was definitely very benefitting for me. Due to assistance of Prof. Faris Ali I gained a lot of priceless knowledge regarding the difficulties in planning experiments, correct interpretation of the obtained furnace tests results and their relevance to the assessment of the capacity of real engineering structures.

Part of the knowledge accumulated here I will use in my future scientific work. I also hope to maintain professional contacts with Prof. Faris Ali, to strengthen research ties between the University of Ulster and the Warsaw University of Technology and the further fruitful cooperation between our universities and us, personally.

Together with Prof. F. Ali we've finally agreed to prepare in a near future a journal paper that will be published either in Polish or British technical journal, on the suitability of the available evaluation methods to assess the capacity of steel columns, built-in the real structural systems, in fire. It is planned the paper will emphasize the problems as well as uncertainties one may face and the inaccuracies they can generate.

I want to express my gratitude to Prof. Faris Ali for his involvement in the organization of the proper conduct of this visit and for his time devoted to me.

And last, but not least I would like to express my special thanks to the COST Office of the European Science Foundation in Brussels and the Management Committee of the COST Action TU0904 for the financial support of my participation in the STSM program at University of Ulster, Fire Safety Engineering Research and Technology Centre (FireSERT), UK.



Paweł A. Król