

HABILITATION THESIS

Fire Design of Civil Engineering Structures

Assoc. Prof. Raul Dan ZAHARIA, PhD
Civil Engineering Faculty
The Politehnica University of Timișoara

ABSTRACT

The thesis summarizes a part of the research activity of the candidate after defending the PhD Thesis at the Politehnica University of Timișoara in February 2000. The selected activity was considered to be relevant in terms of originality and importance, in order to anticipate an independent development of the further research and teaching career. The presentation of the post-doctoral activity is developed within the main thematic direction: “Fire design of civil engineering structures”. A secondary direction is also considered: “Design assisted by testing”.

The candidate was involved in the main topic “Fire design of civil engineering structures” since 2000, after the defense of the PhD thesis, when he obtained a research grant of one year, offered by the Services for Scientific and Cultural Affairs of the prime Minister of Belgium. The research was lead by Prof. Jean Marc Franssen from Liege University in Belgium, a world-wide recognized pioneer in the field of the fire design of civil engineering structures, with decisive contributions in the relatively recent topic of calculation of the fire resistance of structures. The research was focused on the fire behaviour of high-rise steel rack structures and a description of the main results of the research is presented in Part B section 2.5.1 “Fire resistance analysis of high-rise rack structures”.

The relevance of the scientific activity and the recognition of the national and international activity in the field of the first main direction “Fire design of civil engineering structures” is emphasised by the publications of the candidate, mostly in cooperation with European researchers, but also by the involvement in two European technical committees. Another relevant aspect for the recognition of the international activity of the candidate in the field is that he was member of the Scientific Committees for the recent editions of the only two specialised international conferences dedicated exclusively to the structural analysis component of the fire engineering.

The candidate participated at two European COST projects dealing with the fire behaviour of civil engineering structures. The candidate was member of the first Working Group “Fire resistance” of COST Action C26. Within this Working Group, the candidate was responsible together with Beatrice Faggiano, PhD from University of Naples “Federico II”, for the topic “Fire after earthquake”. The relevant contributions of the candidate in this topic are presented in section 2.5.2 “Fire resistance analysis in extreme situations – fire after earthquake”. Within the second COST Action TU0904, which deals entirely with the fire design of civil engineering structures, the candidate is Co-chairman for the Working Group 2, and member of the Managerial Committee. The candidate was one of the five members which presented the first draft of the proposal to the COST Office. One important topic within this COST Action is the validation of the numerical models for the advanced fire analysis of structures. Part of the activity of the candidate on this topic is presented in Part B section 2.3 “Validation of the advanced calculation models for fire design”.

The candidate was responsible for the Politehnica University of Timisoara for three European projects dealing with the first main thematic direction. All these projects, with European partners including universities, research centres and industry, were coordinated at European level by a strong industrial partner, ArcelorMittal Luxembourg. The responsible for these projects was Olivier Vassart, PhD, Head of Structural Long Products R&D at ArcelorMittal and Invited Professor of Steel and Composite Structures at Université Catholique de Louvain, a leader European researcher in the field of fire engineering. Following this

cooperation, the candidate published some papers with Olivier Vassart, regarding the fire resistance of composite steel-concrete floors. Part of the activity related to this topic is presented in Part B section 2.4 “New recommendations for fire design”.

The implementation of the fire design principles is still an on-going process in Romania. However, in the last decade, the candidate calculated the fire resistance of the structural elements for some structures built in Romania. This was a premiere in Romania and, up to this moment, no other similar design cases exist. Part of this activity is presented in Part B section 2.2 “Application of modern fire design in Romania”.

The research in support for new design recommendations was one another activity of the candidate, described in Part B section 2.4 “New recommendations for fire design”.

The cooperation with Prof. Jean Marc Franssen from Liege University continued after the conclusion of the research grant obtained by the candidate in 2000-2001. One part is represented by the research work performed in collaboration with the team lead by Prof. Jean Marc Franssen at Liege University, highlighted by the topics presented throughout Part B section 2 “Fire design of civil engineering structures”. The second part is represented by the publication of two books. The first book (2006) was a world premiere on the topic of fire design of steel structures, being not only a background of the actual Eurocode 1993-1-2, but also a design guide for the engineers, including an introduction into the general topic of fire design. The second book (2009), represented an improved and extended edition of the first one, and included also the relevant fire design provisions from the USA codes. The other author of this book is Prof. Venkatesh Kodur, from Michigan State University, one of the top researchers and teachers in structural fire design in North America. The relevance of these books and their international impact is highlighted by the high number of citations in conferences and journal papers (from which four in journals with high relative impact factor, relevant for the habilitation thesis).

The development of the experimental facilities in CMMC laboratory of the Politehnica University of Timisoara was, since 1994, one of the continuous activities of the candidate. The relevant post-doctorate activity in the secondary thematic direction “Design assisted by testing” is presented in Part B, section 3 of the Habilitation Thesis.

The candidate participated to three major grants in which the CMMC laboratory was substantially transformed by acquisition of new equipments (two as part of the managing team and one as director). Within a “Capacities” type grant, for which the candidate was director, together with the acquisition of new equipments, the laboratory of structures was extended with a new building, which houses a unique facility in Romania and in the Eastern Europe (and one of the few in Europe): an experimental stand for static, dynamic and pseudo-dynamic testing of structural details and real scale buildings. A description of the new experimental facility within CMMC laboratory is presented in Part B section 3.3.

The candidate applied for this grant following the experience gained in the field of pseudo-dynamic testing of real scale building structures within a research grant of two years, wined by competition at the European Commission’s Laboratory for Structural Assessment – ELSA, of the Joint Research Centre –JRC, located in Ispra, Italy, which represents the biggest real scale pseudo-dynamic testing facility in Europe. This activity is presented in section 3.2 “Pseudo-dynamic test of a real scale flat-slab reinforced concrete struture”.

All the scientific, professional and academic future development plans of the candidate deal in principal with the main thematic direction “Fire design of civil engineering structures”.

Even if the main direction for further development is fire engineering, the experience and the activity in the second thematic direction “Design assisted by testing” will allow the candidate to follow also this direction, especially by the realisation of new experimental facilities in the CMMC laboratory, linked to the topic of structural fire research.

A first plan in this direction is to develop the CMMC laboratory capabilities by the acquisition of an electrical system for the local heat of structural elements. This would lead to a unique experimental facility in Romania, which would have the possibility to test a real-scale

structure, heated to a given level of temperature and then loaded with external loads (within the new reaction wall-strong floor experimental facility).

Some research directions were identified for short and middle term, based on actual preoccupations of the candidate and on the numerical and experimental capabilities available at CMMC department:

- Behaviour of composite steel-concrete floors with cellular beams
- Natural fire models – Localised fires
- Validation of the advanced calculation models for fire design
- Fire behaviour of steel connections

One long term objective of the candidate is to properly implement the fire design into the current design practice in Romania. Further courses targeted on fire design of steel and composite steel-concrete structures (EN 1993-1-2 and EN 1994-1-2), are provided to begin from 2014 at national level for civil engineers, within a larger package on EN 1993 design rules. The candidate is in charge with the lectures on the mentioned fire parts of Eurocodes.

The first step for a proper implementation of the fire design practice in Romania is to prepare civil engineers with the knowledge of fire engineering from the university, also through diploma works targeted in this direction. Since 2009, Bachelor and Master Thesis on fire engineering are performed in double coordination by the candidate and by Prof. Jean Marc Franssen, through an ERASMUS agreement with Liege University in Belgium. This agreement was prolonged this year and it is the intention of the candidate (and of Prof. Jean Marc Franssen) to continue this collaboration on long term.

The candidate is attested by the Ministry of Public Works for expertise and verification of the civil engineering buildings projects for fire safety (verification for projects since 2009, Expert since 2009) and intends to continue this activity, related to the authorisation of civil engineering buildings.

The candidate is member of the professional Romanian association AICPS (Asociatia Inginerilor Constructori Proiectanti de Structuri). Through the conferences organised by this associations, or by publications in the dedicated review, the candidate promoted the fire design through presentations and articles on the principles of fire design, or on the particular fire design study cases that he conducted. This kind of activities will continue.

In 2009 was founded the Romanian Association of Engineers for Fire Safety (Asociatia Romana a Inginerilor pentru Securitate la incendiu – ARISI). The candidate was among the founder members and is the president of the Timis Region branch of this association and will continue to support the implementation of the fire design in Romania through this association. It is the intention of the candidate to propose further application guides for Eurocodes EN 1993-1-2, EN 1994-1-2 and EN 1999-1-2 for fire design.

Through the actual research activity related to the localised fires in which the candidate is involved and through its participation in the European Committee for Standardization - Technical Committee CEN/TC 250/SC 01/WG 04 "Actions on structures exposed to fire", the candidate will participate to the improvement of the natural fire models in the Eurocodes.

The involvement of the candidate in some national and international grants as director or managing team member provided the relevant skills and competences on management of such projects. One important aspect in the further development of the career of the candidate is to build a research team focused in the direction of fire engineering at home university. It is the intention of the candidate to recruit further potential PhD students among the students involved in Master Thesis on the topic of fire engineering, especially from the ones which gain an international experience by performing double coordination thesis within the mentioned collaboration with Liege University. It has to be mentioned that the candidate already trained one young researcher from CMMC department in the field of fire engineering, by involving him into the COST IFER activity (including participation to 2 STMS – Short term Scientific Missions) and on the related research of the candidate in the field.