Fire engineering research and postgraduate programmes launched at Stellenbosch University

By: Dr Richard Walls (Stellenbosch University)

Stellenbosch University has established the Fire Engineering Research Unit (FireSUN) which is the first university research group focussed on fire safety in Africa. The team, located within the Department of Civil Engineering, will now be offering postgraduate degrees (MEng and PhD) in fire safety engineering (FSE) and structural fire engineering (SFE). This represents an exciting development for fire safety engineering in South Africa, and Africa as a whole. This article outlines the research, educational offerings and industrial projects currently underway by the team.

Postgraduate programme

In 2018 funding has been generously provided by the Lloyd's Register Foundation (LRF) for the establishment of the first phase of a fully-fledged postgraduate programme in fire engineering at Stellenbosch University, with a view that the educational competency established can be expanded into the rest of Africa. With the growth of the African population and the local mining, manufacturing and resource processing industries the associated fire risks of the continent are rapidly increasing, along with the need for fire engineering professionals. To this end a masters in engineering (MEng) and PhD degrees in fire engineering have been developed to try develop the engineering capacity the continent needs.

Table 1 summarises details regarding the postgraduate programs and topics being offered. The funding received from the LRF has allowed the creation of two taught modules in FSE, namely (a) fire dynamics, and (b) structural design for fire safety. These modules will be rolled out in 2019 and 2020, and will be available to both students and industry practitioners. Existing modules within the Department of Civil or Mechanical Engineering will also be utilised. As the research team grows and more funding is obtained additional taught modules, such as performance-based fire design, will be developed. The main work to be undertaken by masters students will be in the form of a full research thesis, with topics based on the various areas discussed in this article, and to suit the companies getting involved with the program. Two full PhD bursaries are now available, sponsored by the LRF, and local or international students can apply for these using the contact details at the end of this article.

Masters (MEng)	PhD
MEng thesis with topics such as:	Current PhD research is focussed on
 Fire dynamics and design 	informal settlement fire safety, structural
 Structural fire engineering 	fire design for industrial facilities,
 Informal settlement fire safety 	petrochemical plant fire safety, and
- Fire modelling	structural fire design in general.
Core taught modules - Fire dynamics - Structural fire design Additional taught modules for students from a civil engineering background: - Advanced concrete design - Advanced steel design	 Two bursaries/scholarships are available for PhD positions in fire engineering, starting 2019: Structural fire design: Simplified design and analysis of buildings Testing and CFD modelling of fire safety interventions for informal
Additional taught modules for students from a	settlements
mechanical engineering background	

Table 1: Postgraduate programmes in fire safety engineering available at Stellenbosch University in 2019

- Advanced thermodynamics	Full bursary provided for the 3 year
* MEng positions can be reserved by companies	program. Contact the group for more
through the sponsorship of bursaries	information.

In 2019 MEng positions are available to students from a civil or mechanical engineering background. Due to the limited number of positions available the positions will first be available to be reserved by companies that can provide a bursary for their own student to do the degree. Please contact the research group if you are interested in the program.

Current research

As any good fire engineer will tell you – fire engineering is an incredibly broad field with a large variety of specialist topics such as fire dynamics, suppression system design, evacuation, structural fire design, emergency response, detection and much more. The current research group has undertaken a variety of investigations in areas such as informal settlement fire safety, structural fire design, industrial structural design, petrochemical facility fire safety and more. Some of the bigger projects are discussed below.

Informal settlement fire safety

Informal settlement fires occur regularly and affect millions of people in South Africa. Worldwide approximately one billion people live in informal settlements (also known as slums, shantytowns, favelas, or ghettos). In 2017 Stellenbosch University and the University of Edinburgh started on a project called Improving the Resilience of Informal Settlements to Fire (IRIS-Fire). This project follows previous full-scale "shack" fire testing at Stellenbosch [1]. The IRIS-Fire team is busy undertaking research work such as:

- Full-scale fire testing of informal settlements where up to 30-50 dwellings will be burnt in a single experiments. Figure 1 shows a number of tests that have been conducted by the group.
- Modelling of fire spread between dwellings
- Determining fuel loads from extensive surveys
- Utilising satellite imagery for tracking previous fires

In addition to this work the team has been closely involved with the testing and roll-out of smoke alarms in settlements across the Western Cape, as discussed further below.



Figure 1: Full-scale informal settlement fire tests conducted by the FireSUN team

Structural fire design

Structural fire design is a topic typically not well understood by most structural engineers in South Africa. It is believed that many structural engineers are signing off buildings as being safe in the case of fire, when in fact they are not. However, there are codified ways of ensuring that steel, concrete, timber and composite structures are safe in the case of a large fire breaking out.

The FireSUN team has been involved with various research projects on structural fire design such as:

- Thermal and structural fire analyses of an innovative cellular steel building, as shown in Figure 2 and Figure 3, developed by the SA Institute of Steel Construction (SAISC) [2,3]
- Development of a simplified method for analysing multi-storey structures in fire [4]
- Ongoing work is related to the development of fire engineering design codes for South Africa, especially in terms of structural steelwork and the upcoming version of SANS 10162-1 [5–7].
- Design of industrial and petrochemical plants in the case of fire (ongoing PhD project)



Figure 2: Small-scale furnace testing and finite element thermal analyses of a flooring system showing temperatures after 60 minutes of standard fire exposure [3]



Figure 3: Finite element analysis of a cellular beam structural system developed by the SA Institute of Steel Construction exposed to a 60 minute fire [2]

Corporate research

It is important for any research group to stay closely linked to industry and be involved in corporate engineering research. The fire engineering team at Stellenbosch has undertaken various research projects for companies, including:

- Development of a rational structural fire design procedure for the Voidcon decking system. This has involved developing design guidelines to ensure that concrete slabs built with the Voidcon system will satisfy various fire ratings.
- A current investigation, sponsored by Santam, looking at the 1000 homes that were burnt down during the Knysna fire disaster in 2017. It is being investigated how homes could be made more resilient on the wildland-urban interface (WUI), such that fewer homes will be lost in future fires.
- Testing of suppression systems based on full-scale tests.
- Working alongside the Western Cape Disaster Management, Fire & Rescue services to investigate how smoke alarms can be used in informal settlements. In the Wallacedene TRA settlement a smoke alarm was installed in virtually every home and monitored. Real activations occurred in a

number of homes, resulting in lives being saved, with an overview of where fires occurred shown in Figure 4. An exciting promotional video / documentary has been produced on the project which can be found at: <u>https://www.youtube.com/watch?v=-z5SkDZtA3U&t=7s</u>.



Figure 4: Following testing done at Stellenbosch University, many thousand smoke alarms have now been rolled out across the Western Cape in informal settlements. The figure above shows where activations occurred in the Wallacedene TRA settlement after the installation of a smoke detector in every dwelling [8]

The FireSUN Team

Although the fire engineering team at Stellenbosch University was only founded in 2017 it has grown rapidly. It 2019 it will have approximately 1 post-doctoral researcher, 5 PhDs, 8 MEng students, and 5 honours students working on research projects. Pictures of current and past team members are shown in Figure 5. The team is led by Dr Richard Walls, a consulting structural engineer, who now likes burning things down.



Figure 5: The FireSUN team (from top left to bottom right): Dr Richard Walls (team leader), Dr Charles Kahanji (researcher), Antonio Cicione (PhD), Dineo Ngwenya (PhD), Njabulo Zimba (PhD), Janeke Volkmann (MEng), Jaleel Claasen (MEng – AECOM Fire bursary), Junior Fourie (MEng), Stefan Loffel (MEng – AECOM Fire bursary), Michael Kloos (MEng grad. 2017) and Hendrig Marx (MEng grad. 2017)

Further information

If you would like any additional information regarding the postgraduate programmes, current research, industry consulting or any other aspects you can contact the FireSUN team at <u>fire@sun.ac.za</u>. Funding and technical partners are being sought to establish a fully-fledged fire engineering program. Please free to contact us in this regard.

References

- R. Walls, G. Olivier, R. Eksteen, Informal settlement fires in South Africa: Fire engineering overview and full-scale tests on "shacks," Fire Saf. J. 91 (2017) 997–1006. doi:10.1016/j.firesaf.2017.03.061.
- [2] M. Kloos, An investigation into the structural behaviour of a novel cellular beam structure in fire, Stellenbosch University, 2017. http://scholar.sun.ac.za/handle/10019.1/102683.
- [3] H. Marx, Thermal behaviour of a novel cellular beam structural system in fire, Stellenbosch University, 2017. http://scholar.sun.ac.za/handle/10019.1/103350.
- [4] R.S. Walls, A beam finite element for the analysis of structures in fire, PhD Thesis, Stellenbosch University, 2016. http://scholar.sun.ac.za/handle/10019.1/100331.
- [5] R.S. Walls, C. Viljoen, A comparison of technical and practical aspects of Eurocode 3-1-1 and SANS 10162-1 hot-rolled steelwork design codes, Civ Engr S Afr. 58 (2016) 16–25.
- [6] R.S. Walls, C. Viljoen, H. de Clercq, J. Retief, A critical review on current and proposed structural fire engineering codes for steelwork in South Africa, in: S.O. Ekolu et al (Ed.), Constr. Mater. Struct., IOS Press, Johannesburg, 2014: pp. 1134–1140.
- [7] R.S. Walls, M. Botha, Towards a structural fire loading code for buildings in South Africa, in: Insights Innov. Struct. Eng. Mech. Comput. - Proc. 6th Int. Conf. Struct. Eng. Mech. Comput. SEMC 2016, 2016.
- [8] P. Zweig, R. Pharoah, R. Eksteen, R.S. Walls, Installation of Smoke Alarms in an Informal Settlement Community in Cape Town, South Africa Final Report, 2018.