Fire Technology, 51, 1511–1513, 2015

Manufactured in The United States
DOI: 10.1007/s10694-015-0517-7

Book Review

Tunnel Fire Dynamics

Haukur Ingason, Ying Zhen Li & Anders Lönnermark. Springer, New York, 2015. 504 pp, ISBN 978-1-4939-2198-0

I entered the field of tunnel fire research in 1998, about a year before the Mont Blanc Tunnel fire happened. At the time there were few research publications on the subject of tunnel fires and most of the ones I was able to find in my first literature review were written or co-written by Haukur Ingason. In my first year of study in this field I amassed a pile of reports and papers by him and I remember thinking at the time that it would be good if he had written a book on tunnel fires!

Following the spate of tunnel fires at the turn of the century, Dr Alan Beard and I were invited to edit the ''Handbook of Tunnel Fire Safety'' (1st Edition 2004, 2nd Edition 2011, published by ICE Publishing) and we sought out the best people working in the field to contribute chapters. Of course, we immediately invited Haukur to contribute the chapter on 'Tunnel Fire Dynamics'; Alan and I still consider this chapter to be the essential heart of our handbook. The new book that has now been published, some 17 years after I originally wanted it, is essentially a greatly enhanced, updated and fully fleshed out expansion of that chapter. This is still the heart of tunnel fire safety, now expressed in detail.

While Prof. Ingason has been working full time in tunnel fire studies for the past two decades or so, he has not done so alone. Along the way has supervised some others through their PhD studies and guided them into full time research in this field as well. His two co-authors on this book are two researchers he mentored in this way and continues to work with at SP, Sweden.

This book seeks to be a comprehensive explanation of fire behaviour in tunnel environments. The book wears its heart on its sleeve and states its intent clearly (and repeatedly) at the outset. Its intention is to convey an understanding of ''fire physics'' to the reader (variations on the phrase 'fire physics' seem to appear on almost every page of the introductory chapter). This aim is probably the book's greatest strength and also its greatest weakness. This focus on physics, expressed using many equations, will inevitably be attractive to some readers and will alienate some others. This is not a book that contains something for everyone but is rather one which contains everything for someone.

Given the stated intent of the book, the subjects covered are broadly what you might expect. After some introductory chapters, including a detailed survey of fire testing in tunnels, we get chapters on ''Heat release rates in tunnels'', ''Fire growth rates in tunnels'' and ''Design fire curves''. The book then goes into more detail looking at aspects such as ''Gas temperatures'', ''Flame length'', ''Heat flux and thermal resistance'' and ''Fire spread''. In each chapter the subject is introduced by studying the theory, reviewing the literature relating to fires in the open or in enclosures, then discussing the application to the tunnel environment. As such, this book serves as a guide to fire dynamics in general, not only to fire behaviour in tunnels.

The chapter on ''Design fire curves'' needs special comment. The industry needs to use fire 'curves' for the design of the structure and structural protection systems, and for ventilation system design. Thus a good discussion of design fires is what practicing engineers would want to find in this book. In practice, structural questions are addressed using time–temperature curves while questions to do with smoke control generally use fires defined by a peak heat release rate or, less commonly, a fire growth rate. There are numerous issues with the structural time–temperature curves which could have been discussed here, but are not mentioned. Indeed, this book is almost entirely lacking in discussion of structural fire engineering issues. Beyond that, rather than discussing the state of the art in design fires, the authors use this chapter to present and promote their own, somewhat convoluted, methods for defining a design fire. While it is interesting to see how a complex vehicle can be represented by a single mathematical expression, the practical application of this in system design is not clear.

For most of its length, however, the book is not used as a platform for the authors to promote their own opinions. A lot of research works from SP are discussed, but this is entirely appropriate as they have been leading the field in tunnel fire research for the past two decades. Beside this, a vast library of research from others is also presented. This is most evident by simply reviewing the sheer number of references cited, with most chapters having at least 30 references, some many more.

As is commonly noted in the fire safety community, it is usually smoke, not the fire itself, that leads to injuries and fatalities in fire incidents. The same is true in tunnel fires. It is perhaps somewhat surprising then that this book, having devoted over 300 pages to the question of fire behaviour in tunnels, spends only about 80 pages on the subject of smoke behaviour, in chapters 12 to 15. (Chapter 7 on ''Combustion products from fires'' concerns smoke as well, but even counting that less than 20% of the book looks at smoke.) The chapters address ''Smoke stratification'', ''Tunnel fire ventilation'', ''Visibility'' and ''Toxicity''. Given the importance of understanding smoke behaviour in tunnels, it is surprising that there is no chapter which addresses the question of smoke production directly. Yields of toxic gases and soot are discussed in chapter 7 and entrainment is briefly discussed in chapter 12, but the book does not unify these and other relevant topics into a discussion which satisfactorily answers the question of ''how much smoke is produced?'' Given that this is of primary relevance to the design of ventilation systems for life safety, this is a significant oversight.

The book concludes with three chapters on fire suppression, CFD modelling and experimental scaling techniques.

The chapter on suppression provides a useful and fairly bias-free discussion of the various suppression fire test series which have been carried out in Europe in the past 15 years, from the tests in the 2nd Benelux tunnel in 2001, through UPTUN and SOLIT, to more recent tests carried out by SP in the Runehamar tunnel. The theory of fire extinction is presented and various types of suppression systems are discussed. The practical application of these results and the limitations of such systems are only briefly addressed.

The chapter on CFD covers well trodden ground and is perhaps the chapter here with the least relevance to tunnel fire safety. This chapter spends most of its length answering the question "what is CFD?" and not enough of its length addressing tunnel-specific questions. Most engineers working in the fields of tunnel ventilation or fire safety already know these basics, and anyone working with CFD for tunnel applications would need a lot more information than is presented here for a useful resource.

Finally, and rather oddly, the book looks at "Scaling technique". This subject is crucial for understanding the application of the results from some of the reduced scale testing already presented in the book, so to leave this discussion until the end is a strange editorial choice. However, this chapter is a good and detailed discussion of what can and cannot be learned from reduced scale testing.

So at the end we must address the question of who will find this book useful? I cannot help but feel that the implied reader of this book is an experimental fire researcher, much like the three authors themselves. There are some working in the fields of tunnel design and safety engineering who will be put off by the sheer volume of equations in this book. There are engineers who will not find the answers to their questions here. Indeed, this is not a book of answers, it is a book intended to equip the physics-literate reader with all the knowledge to be able to answer the questions for themselves. This is a good thing. There are no simple 'one size fits all' solutions for tunnel safety. This book will prove to be an excellent resource for those prepared to put in the effort and work out their own solutions for their own unique tunnel problems.

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