J. of Fire Prot. Engr., 5 (4), 1993, pp 141–146

INTERNATIONAL IMPLICATIONS OF PERFORMANCE BASED FIRE ENGINEERING DESIGN CODES

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SUMMARY

The trend towards performance-based design codes for fire safety design of buildings will provide greater busimess opportunities for international fire engineering firms. A common set of engineering tools and quantitative design methods based on a universal fire science will also encourage this process.

Examples of performance-based approaches to fire engineering are presented as evidence of growing international cooperation. There are constraints, however, on transnational engineering opportunities. These are identified and include the lack of standards harmonization and differences in product approval and building permit processes between countries.

INTRODUCTION

An international trend towards building fire safety design codes that are performance-based rather than being highly prescriptive is now becoming clearly evident.

The advantages of the performance-based approach are thought to be more cost effective fire protection, greater flexibility in design, and achievement of measurable and consistent levels of safety.

Bukowski and Tanaka[1] indicate that this move towards performance-based design started in Japan as far back in 1982. Similarly, we have seen major developments in risk assessment based design in Australia through the Warren Centre project[2] and the Building Regulation Review Task Force program[3]. This work has been extended further with Australian-Canadian collaboration through the National Research Council of Canada (NRCC) that has resulted in design approaches that use risk assessment as the measuring tool for establishing whether life and safety goals have been met[4].

In U.K. and other European countries, moves towards performance-based design are also growing. Law[5] reports that recent changes in the U.K. Building Regulations (1985) have seen highly prescriptive requirements for fire safety replaced by simple functional (performance) statements such as:

> B(3)-(1) The building shall be designed and constructed so that in the event of fire, its stability will be maintained for a reasonable period.

This U.K. move towards performance-based design is reflected in Europe where Law[5] indicates that the Construction Product

Directive uses simple functional statements for the "essential requirements" such as fire safety, that have to be satisfied.

Finally, New Zealand has taken a major step towards a performance engineering approach to fire safety design of buildings with a new Building Code which requires quantitative engineering calculations.

Clearly, there are international implications of performance-based fire engineering design codes and opportunities for designers that are reflected in the interest expressed around the world in the work of the International Standards Organization Committee ISO/TC92/SC4 on fire engineering methodologies. This paper looks at those "global engineering" opportunities that are arising from increased use of performance-based building codes and some of the limitations that still exist.

INTERNATIONAL OPPORTUNITIES FOR DESIGNERS

This trend towards performance-based design does open up the international opportunities for the fire protection engineering profession. Of necessity, performance codes simply "establish the safety goals and leave the means of achieving those goals to the designer," as Bukowski and Tanaka[1] suggest.

Performance approaches require the use of deterministic and probabilistic engineering relationships that are fundamentally based on fire science that is universal. Hence far greater international opportunities arise for engineering firms to consult across national boundaries because this universal science of the fire engineering professional is "transportable". Design fires described in heat release rate (kW), fire models such as FAST and life threatening conditions of 43,000 ppm min CO are the same in whichever countries engineers work.

By contrast, highly prescriptive building codes usually have many rules based on experience with large numbers of exceptions and exclusions that have no fundamental basis. Where this is still the situation, and no equivalence provisions of opportunities for an engineering approach are provided, limitations on entry of non-local fire engineers often requires a learning curve that is too steep.

A good example of international involvement in a major project is that by the U.K. based Ove Arup and Partners through Paula Beever and her involvement in the design of the Kansai International Airport Terminal Building in Japan. A novel engineering approach[6] of "Cabins and Islands" using quantitative engineering tools saw a fire safety performance approach that was not only highly innovative but entirely cost effective and appropriate in a complex situation. Based on selected design fires, Beever was able to estimate the times of operation of sprinklers using the DETACT software and estimate smoke filling and extraction rates using Heskestad's equations. She also used radiant flux calculations and ignition data to show that fire spread between combustible furniture and luggage "packages" could not occur. Similar approaches to design using quantitative engineering methods have more recently been applied to airports in Australia.

Another example is the refurbishment plans for a major high rise office tower in the center of Melbourne, Australia[7]. Here a total performance approach to the fire safety upgrade of the so-called "140 William Street Building" saw a design accepted by the local council authority having jurisdiction based on a risk assessment and fundamental engineering approach supported by limited full-scale experimental verification. Of enormous interest is the fact that much of the structural steel now has no fire resistance cladding, but the building will be equipped with the latest fire detection, sprinkler and evacuation equipment allowed by the performance approach. The risk assessment methodology for 140 William Street was based on event tree analysis and Monte Carlo simulations into which data was fed on time and probability of key events. This input data was derived from fire models, reliability and fault tree analyses, statistical information and experimental data, especially on structural performance, from the large fire test experimental work.

It is true to say that this approach to fire safety design was not universally accepted in Australia, with concern expressed by the Melbourne fire authorities and others. However, it is the type of approach that is potentially open to a wide range of international fire engineering consultants to cross national boundaries when full performance based approaches are utilized and fundamental analytical techniques are permitted to be used.

Fire Engineering Tools

The opportunities for transnational fire engineering consulting are confirmed when one looks at the tools used by fire engineers in different parts of the world.

The first attempt to put together a series of analytical prediction methods for fire safety design was undertaken by Lawson and Quintiere[8] in 1988 in their paper "Slide Rule Estimates of Fire Growth." Subsequently, a number of these and other prediction methods were converted into computer software in at least three formats worldwide, namely:

FIREFORM in the USA[9]

FIRECALC in Australia[10]

ASKFRS in the U.K.[11]

All programs are similar and use the fundamental equations developed by Thomas, Quintiere, Babrauskas and others that are familiar to most international practitioners.

The HAZARD I package developed by Bukowski and others at NIST[12] has similarly gained international acceptance and use. Training courses on Hazard I have been conducted by Barnett and Beyler in USA, Australia, U.K. and New Zealand.

In the standards area, UL 217[13] has become the *de facto* "international standard" for domestic smoke detectors with many national standards using UL 217 as the basis of their specifications. This applies in Australia where AS 3786[14] is based closely on UL 217.

The NFPA standards 13D and 13R for domestic and residential sprinklers are being widely used in Australia as another example of the adoption of fire engineering technical documents across international boundaries. Australia has also introduced much of the associated technology involving use of plastic pipe and residential sprinkler heads.

It is true that UL 217 and NFPA 13D/R are not yet performance-based standards. However, despite this fact, these standards set the requirements for products or components that use the latest technology and are traded internationally in a global market. For example, U.S. manufacturers of fast response, extended coverage and large drop sprinklers find acceptance of their American products in many countries in the Australian and Asian region without special engineering changes for these markets.

In the case of fire detection and alarm audibility, the new course in Building Fire Safety and Risk Engineering at Victoria University of Technology (VUT) in Melbourne has used the WPI video teaching series[15] developed in the USA. The series produced for North American audiences is perfectly suitable for Australian trainee fire protection engineers as it is fundamentally based on internationally accepted science and engineering.

One last example is the proposed "Operation Global Firesafety" planned for Melbourne, Australia in 1994/5[16]. It will form part of the Fire Code Reform Project[17] and is aimed at developing and validating, through a major fire test program, the performance-based fire engineering methods currently used in practice in Australia and other countries to achieve fire safety of buildings.

Operation Global Firesafety will examine performance of new technologies such as halon alternatives, water mist, and advanced sprinkler types in both the residential and electronic equipment occupancies. A design package of fire safety measures will be engineered using available computer models and other design tools and then compared with experimental results from full scale tests. This is a major international cooperative effort with significant global benefits to the fire research, engineering and regulatory communities. Interest has been expressed already by researchers and fire engineering practitioners from the USA, Canada, the U.K., Switzerland, and many Asian countries.

It is clear that the tools of fire safety design, and the science upon they are based, have a fundamental international foundation that allows a cross fertilization of fire protection engineers and a sharing of a common body of knowledge. The implications are that the rate of growth and acceptance of performance-based methodologies will accelerate much more rapidly than if all countries are working in isolation. The technology transfer between countries means that international collaboration will flourish. Significant engineering and research consulting groups with members from different countries are already in evidence and this trend will continue.

Limitations on International Designers

While international opportunities for engineering firms will grow as building codes move towards performance requirements, they will largely be limited to conceptual design with local engineers left to do the detailed design documentation. The reasons for this are that often local knowledge will be required to understand the complexities and politics associated with:

- local standards
- product approvals
- authority permits.

In relation to installation standards, many are still written in prescriptive fashion such as sprinkler design codes. NFPA 13 and Australian Standard 2118 for automatic sprinklers relate water requirements to occupancy classification and do not allow for the calculation of the fire size or time at the point of sprinkler head operation. The codes have complex layout rules and are elaborate installation documents rather than true engineering codes. Until these codes utilize fundamental concepts such as ADD/RDD and RTI, they will not be easily usable or understood by international consultants. The problem is that standards are just too complex, and include many subtleties that are not appreciated unless used on a very regular basis.

Product performance standards also hinder easy access for international firms in many markets. The differences between the USA and European product standards and tests have recently been highlighted by Babrauskas[19]. For example, the European reaction to fire test may be based on the ISO9705 room/corner test with small scale tests using the ISO5660 cone calorimeter standard also permitted. This contrasts with the totally different ASTM E84 Steiner Tunnel test for wall/ceiling linings still used in the USA that does not provide fundamental engineering data. Therefore, designers desiring to cross international boundaries may find difficulties understanding and using standards that are not fundamentally based and with which they are unfamiliar.

A related problem is product approvals on active fire protection provisions such as sprinkler heads, smoke detectors and evacuation equipment. There are still very few international standards in this area, and major differences exist between national test methods and procedures for listing or approval of equipment by test laboratories. For example, the Australian Standard AS 1603.2 is very different to UL 268 for smoke detectors, having many different test methods and significantly different fire tests and sensitivity criteria.

As a result of these differing standards, international consultants moving into a new country can have difficulties specifying equipment to test standards which may be difficult to understand and have not been internationalized. There are some moves in the area with the recent signing, for example, of an agreement between Factory Mutual Research Corporation (FMRC) and the author's laboratory, Scientific Services Laboratory (SSL). This agreement provides for mutual acceptance and exchange of product test reports and technological dialogue between researchers and approval managers. FMRC has similar agreements with VdS (Germany) and other European laboratories. SSL has cross accreditation with Hong Kong Fire Brigade. Growth of similar arrangements may well lead eventually to international recognition of fire equipment test laboratories and harmonization of product approvals that will facilitate international engineering design and world-wide product marketing, but this is still some years off.

Finally, the project permit process that enables local authorities having jurisdiction to accept a design and issue a building approval varies widely from country to country. This means that lack of local knowledge often inhibits the best international engineering consultants from winning contracts for major projects.

The difficulties with understanding particular standards and processes for product approval and building permits may be overcome somewhat by the international fire safety consultant networking with local consulting and construction firms. These firms provide the detailed local knowledge and design documentation, approvals and permits skills that are needed to ensure a project proceeds to completion in a cost-effective manner. Loose collaboration or formal joint ventures are ways of achieving local use of international consultants. This has worked very effectively in China in many engineering fields.

In the future, moves towards performance-based building regulations, use of full engineering methodologies and joint tendering by international firms in association with local companies may see the importance of local knowledge diminish.

FUTURE ACTION

In summary, the trend towards performance-based design codes is going to provide greater business opportunities for international fire safety engineering firms. A common set of engineering tools and quantitative design methods will enhance this process. However, this global engineering approach will remain somewhat restricted unless further harmonization of international design standards, product approvals and building permit processes are achieved.

Another limiting factor on acceptance of performance-based fire engineering methodologies is the acceptance criteria or regulatory goals of fire safety/building codes. In Australia risk to life and fire costs of alternative fire safety designs must be equal to or better than the levels inherent in the governing Building Code of Australia[18]. However, this approach is not universally accepted and definitions of quantifiable levels of fire safety in buildings must be a major international objective in the future.

The FORUM of fire research organizations exists to co-ordinate international research activities in this field. A similar initiative on fire safety engineering methods, acceptance criteria, product approval mechanisms and perhaps permit processes is required. The Society of Fire Protection Engineers (SFPE) may be one of the best vehicles to facilitate this development of such an initiative through its broad international contacts. Organizations such as ISO/TC92 and CIB/W14 are other possible international vehicles for this work.

ACKNOWLEDGEMENT

The permission of the Manager, SSL to present this paper is gratefully acknowledged.

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