Fire Engineering Practise: A UK Practitioners View

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Abstract

This paper details the results of a questionnaire survey that targeted experts in the field of fire engineering to review current practice within the design process and how designers, architects, fire safety consultants and other professionals view the costs and cost benefits associated with fire protection applied to buildings. The paper concludes that: there is a lack of tools that provide information on the cost benefits of installing protection measures, especially those related to passive fire protection; and that professionals involved in the design of buildings would make use of such a tool.

Keywords: fire engineering, BS 9999, Questionnaire survey, Passive fire protection; Building design tool

1. Introduction

The cost effectiveness of various fire protection measures have previously been investigated and published in various research papers (Butry, 2009, Li and Spearpoint, 2004). However, the majority of the work reported has focused on active measures with little attention given to investigating the costs of passive fire protection and how these affect the cost benefits in a fire protection plan. Most previous studies have focused on fire protection used in the chemical industry (Tyldesley et al., 2004) and in offshore structures (Shetty et al., 1998). Data on the cost benefits of passive fire protection (PFP) measures in the construction industry is not yet available. Therefore this research is investigating how PFP measures within buildings can be implemented cost effectively and if this practice already occurs within the fire engineering industry.

Previous work by Ramachandran (Ramachandran, 1998, Ramachandran, 1995) has identified aspects of fire engineering that benefit from the addition of cost effective installation of protection measures. His work has provided a firm foundation on which to base a proposed design tool.

If the investigation reveals that the cost effectiveness of PFP measures is not considered in practice, it is the intention to find out why and what steps or tools can be used to promote more cost benefit analysis of PFP measures to allow for more cost effective building fire protection.

Therefore the objectives of this research are:-

- Investigate current practice in the fire protection of buildings
- Analyze fire incident data from the UK fire services
- Construct tools to support decision making for fire protection decisions in building design

The investigation of current practice is discussed in this paper. The next stage of the research will then focus on the analysis of fire incident data from the UK fire service. The results will then be fed into a methodology and a tool to consider the cost benefits of fire protection during the design of buildings.

2. Data Collection

Collecting data on the costs related to PFP in the building industry is of no importance if the results are not considered by the professionals specifying the protection measures. Therefore the first part of the research is to find out what measures fire professionals use, how the new guidance in British Standard 9999 (BSI, 2008) is being used and if this had changed the working practices and methods of practitioners.

This was done through a questionnaire distributed to experts involved in building design, such as fire protection engineers, consultants, architects and building control officers. The survey was designed to cover various aspects of fire protection in buildings and was split into four parts: the design process, cost of fire protection, fire protection methods and the use of BS 9999.

2.1 The Design Process

This section was used to find out more about when respondents got involved in the design and building process and their role in the fire safety of the building. The design stages defined in the RIBA plan of work (Royal Institute of British Architects, 2007) for ease of comparison between the different professions involved in the survey.

Respondents were also asked whether they only focused on life safety aspects as part of their role in the process. The primary concern of the building codes in the UK is to ensure that buildings are designed to provide a safe egress for occupants in event of a fire. However other aspects should be considered such as property protection and insurance requirements. Some British codes and guidance are beginning to include sections for property protection, such as Building Bulletin (BB) 100 (Department for Children, Schools and Families, 2005). The questions in this section were designed to show how widespread alternative considerations were and how these could be considered by this research.

Lastly, the respondents were asked if the buildings they are involved with complied with the building regulations or met the standards laid down in the regulations in a different manner, how did they check or validate designs that were non code compliant and how they put their designs through building control (the British regulatory body). Respondents were also asked if they thought that building designs were accepted or rejected by building control officials due to a lack of understanding of fire engineering principles.

2.2 Costs of Fire Protection

In the next section of the questionnaire, respondents were asked if cost was a critical factor in design decisions. If respondents did not take into account costs, then there would be no point in investigating the cost benefits of PFP, as even if it is economically advantageous to install more PFP than the codes required, respondents would not consider these implications. They were also asked if they considered the costs of the fire protection methods they specified for buildings.

Respondents were also asked if they would use cost benefit tools or cost effectiveness data if they were available to establish whether these would be useful outputs from this research. The last two questions in this section focused on the costs of passive fire protection and on sprinkler systems. Firstly to establish if the respondents ever used more PFP than a building code specified so that the building gained a reduction in insurance premiums and secondly if they thought that sprinklers were a cost effective solution over the course of a building's life cycle.

2.3 Fire Protection Methods

This section focused on how the respondents view fire protection in general. The first two questions focused on whether or not inherent safety (inherent safety in this case refers to the building being safe even if a protection system fails to contain the fire) was considered in building design and if any redundancy was also built into the design. These questions were designed to find out how design decisions were taken, for example, if active systems were used as additional protection should passive protection measures fail.

The last three questions focused on the passive protection measures within the building. Whether respondents design extra protection rather than that described in the codes, (this question differs from the one above in the costs section as this is to find out if they install extra measures for non cost related reasons). In the final two questions, the respondents were asked to rate how essential and how effective they thought passive fire protection was within a building.

2.4 BS 9999

The last section of the questionnaire focused on BS 9999. This new code in the UK, combines performance based codes and the old prescriptive codes such as BS 5588 (BSI, 2004). This new code enables designers to design the building for its future use with a greater degree of flexibility. For example, Approved Document B (ADB) (Communities and Local Government, 2006) which provides the simplest method of meeting the building regulations in the UK can be interpreted as a prescriptive document and it gives guidance on compartment dimensions of building occupancy types without taking into account the actual, final occupancy of a building. For example, it doesn't take into account that a warehouse storing non flammable goods is less of a fire risk than one storing highly flammable goods. This leads to the fire safety installation in the non flammable goods warehouse being more complicated than necessary. BS 9999 addresses this by the use of a risk profile for each building which is calculated according to two characteristics: occupancy and fire growth rate. The risk profile is derived from Tables 1 and 2.

Table 1: Occupancy Characteristics (from BS 9999: Code of Practice for Fire Safety in the Design Management and Use of Buildings, page 26).

Occupancy Characteristic	*Description*	*Examples*
A	*Occupants who are awake and familiar with the building*	*Office and industrial premises*
B	*Occupants who are awake and unfamiliar with the building*	*Shops, exhibitions, museums, leisure centres, other assembly*

		buildings, etc.
Ci	*Occupants who are likely to be asleep: Long-term individual occupancy*	*Individual flats without 24 h maintenance and management control on site*
Cii	*Occupants who are likely to be asleep: Long-term managed occupancy*	*Serviced flats, halls of residence, sleeping areas or boarding schools*
Ciii	*Occupants who are likely to be asleep: Short-term occupancy*	*Hotels*
D	*Occupants receiving medical care*	*Hospitals, residential care facilities*
E	*Occupants in transit*	*Railway stations, airports*

This occupancy characteristic is then combined with the fire growth rate characteristics of the building, a basic measurement of how fast a fire would grow in the premises. This is shown in Table 2.

Table 2: Fire Growth Rate (from BS 9999: Code of Practice for Fire Safety in the Design Management and Use of Buildings, page 26)

Category	*Fire growth rate*	*Examples*
1	*Slow*	*Banking hall, limited combustible materials*
2	*Medium*	*Stacked cardboard boxes, wooden pallets*
3	*Fast*	*Baled thermoplastic chips, stacked plastic products, baled clothing*
4	*Ultra fast*	*Flammable liquids, expanded cellular plastics and foam*

Using these two tables, it is possible to assign a risk profile to the building use and thus guide the design decisions. For example, an open plan office is given a building profile of A2 whereas a closed plan office is given a profile of B2. This gives the designer greater flexibility and avoids making the design more complicated than it needs to be, thus creating a cost effective solution.

The questions in this section were designed to see if this new code had changed the respondents methods of working, the design time, and how often this code is used over other building codes such as ADB and BS 7974 (BSI, 2003) . Respondents were also asked if the design time had changed as a result of change in design code.

Finally, respondents were asked if they thought the code was too complicated and whether it imposed greater constraints on fire engineers. These are common issues raised; furthermore, in a presentation for the Institution of Fire Engineers, Hedges raised the point that BS 9999 could potentially reduce the scope for fire engineering (Hedges, 2009).

3. Analysis

The survey was distributed using various channels to the respondents:-

1. Sixty-eight architects, seven building control offices and seven fire consultancies were contacted via email

2. All sixty-six delegates at the first Fire Risk Management Conference at Loughborough University held in April 2010 (http://irmp.lboro.ac.uk/news.php)

3. It was placed on the projects website (http://irmp.lboro.ac.uk) via Google Apps (the questionnaire can be found here – http://goo.gl/JzaNA) for anyone sent the link to complete. The link is not visible on the project page to avoid random viewers entering false data and skewing results.

The questionnaire was aimed to find out individuals views, rather than company views. When approaching companies, it was asked that as many individuals as possible could fill in the questionnaire. Delegates at the Fire Risk Management conference had all day to fill in the questionnaires and were also provided with a stamped address envelope so that the questionnaire could be completed after the event in the respondents own time and thus time should not have been a factor in the delegate's replies.

Twenty two questionnaires were returned, giving a response rate of 12%. Of these, six were from the conference, nine were from direct emails and the other seven were gathered from the online survey. There was a mixture of architects, building control officers, fire service personnel and fire engineers.

The response to the survey was low – fire engineers are a specialist field within the building industry and many of those, work for large engineering consultancies. Therefore the response rate was low due to the companies involved only providing one engineer to answer the questionnaire.

3.1 Design Process

The majority of the respondents did not conduct risk assessments but the nine respondents that did, used a mixture of internally developed systems, along with guidance such as PAS 79 (BSI, 2007) and HTM 5-03 Part K (Department of Health, 2008). In all cases where a fire risk assessment was carried out, respondents stated that they either used the guidance and thus the methods in them or they had an in-house system. No one stated that the guidance was incomplete or lacking, though the use of in-house systems could imply that the methods laid out in the available guidance were either not clear or the in-house system could perform better.

The results indicate that respondents got involved in projects at different stages which reflect the different disciplines involved in the survey, this is shown in Table 3. However, some respondents indicated more than one stage which accounts for the numbers within the table adding up to more than the number of respondents. It may appear that the number of fire engineers responding is low - note that some respondents used the general term consultant to cover the work they did, even though the work they did was fire engineering.

Table 3: When do you get normally get involved in a project?

	Preparation	*Design*	*Pre-Construction*	*Construction*	*Operation/Use*
Fire Safety/ Risk Management	*2*	*4*	*3*	*2*	*4*
Building Control	-	*1*	-	-	-
Fire and Rescue Services	-	-	-	-	*1*
Architect	*3*	*3*	*3*	*3*	-
Fire Engineer	*1*	*1*	-	-	-
Consultant	*1*	*6*	-	-	-

Table 4: When would a more suitable time to be involved?

	Preparation	*Design*	*Pre-Construction*	*Construction*	*Operation/Use*
Fire Safety/ Risk Management	*2*	*2*	*3*	*2*	*3*
Building Control	*1*	-	-	-	-
Fire and Rescue Services	-	-	-	-	*1*
Architect	*2*	*2*	*1*	*1*	*1*
Fire Engineer	*1*	*1*	-	-	-
Consultant	*3*	*4*	-	-	-

Tables 3 and 4 show very close figures, indicating that the various respondents get involved in a project at the stage that they think is the most suitable. When asked if the stage of involvement of fire safety experts could affect costs, all but one respondent agreed that it would affect the final cost of the project. The one expert that answered no, however, elaborated on his answer and stated that "No - In some instances it saves money in the long run". This is taken as being an affirmative answer, as saving money is an effect on the final cost.

Regarding the main focus of fire protection, thirteen respondents stated that their designs focused on other aspects in addition to life safety; including property protection, insurance risk and compliance and heritage considerations. Of these thirteen respondents, nine answered that property protection and compartmentation of the building were important aspects considered alongside life safety. One respondent who answered that the primary focus of the designs was life safety did also note that "there is an attempt to resist further building damage therefore providing an economic consideration". This is taken to imply that whilst the main consideration in a building design is life safety (i.e. the focus of the codes), the majority of people involved in the fire engineering industry are considering other aspects of protection and most notably, protection of property.

In terms of code compliance, the majority of buildings comply with the codes apart from small non-compliant sections which require validation. The methods that the respondents used to validate and verify the design differ, depending on the respondents' own profession. The majority of architects, for example, stated that they would employ fire safety engineers to do the validation for them. The engineers, for their part, responded that they used building codes such as BS 7974 or CIBSE Guide E (The Chartered Institution of Building Services Engineers, 2003) to aid them in the validation.

Fire engineers use different methods to prove that designs are equivalent to the codes. They do this through the use of design guides, discussions with building control officers and the use of ASET/RSET (Available Safe Evacuation Time and Required Safe Evacuation Time) comparison.

When questioned about the building design review process, results from respondents inferred that building control officers need a better understanding of fire engineering principles to improve the speed and efficiency of the building design review process. This is because twenty respondents believe that building control officers accepted plans when they did not understand the fire engineering principles and sixteen respondents believe that building control officers rejected plans when they did not understand the fire engineering principles.

3.2 Costs

In terms of costs, only fifteen respondents considered cost as a critical design factor but twenty one said that they considered the costs of individual protection measures they specified. Twenty respondents also stated that they believed that sprinklers were a cost effective addition to the building however fewer respondents stated that they would use extra passive protection to reduce insurance and other costs in the same way that sprinklers are employed. Whether this is due to the lack of research on the cost benefits of passive fire protection, a lack of insurance related data showing benefits at the design stage or an overreliance on active measures remains unclear. It does however show an inconsistency between those willing to install sprinklers and those willing to go above and beyond the required passive protection. However twenty respondents stated that they would make use of a tool that calculated a more cost effective solution to a problem.

3.3 Fire Protection

When asked about passive fire protection, respondents overwhelming stated that they thought it was an essential part of a fire engineered design however not as many respondents thought it was as effective as it was essential. Table 5 shows the responses given.

Table 5:How essential and how effective is passive fire protection?

Scale – 5 being very and 1 not at all	*No. Of Respondents*	
	Essential	*Effective*
1	*0*	*0*
2	*0*	*1*
3	*3*	*7*
4	*6*	*12*
5	*13*	*2*

It clearly shows that respondents thought that passive protection was required even though they were not as confident that it was effective. It was not made clear why they thought the protection was not as effective as it was essential. However, articles in industry journals, such as Parlor's article in *Fire Safety Engineering*, (Parlor, 2009) Rowan's and Schulz's articles in *Fire Risk Management* (Rowan, 2010, Schulz, 2009) raise issues regarding the correlation of the satisfactory installation of passive protection and the lack of inspection during construction of a building to ensure that fire safety provisions are constructed correctly.

Even though all respondents viewed passive fire protection as essential (to a degree), about a third responded that they would not install more than the required amount of passive fire protection measures within a building, over that required by codes. One respondent stated he would only do it "where required by insurers". However all respondents stated that they considered inherent safety within the building.

3.4 BS 9999

Regarding BS 9999, half the respondents thought the code was too complicated. This was across the range of respondents questioned and included architects, consultants, building control and fire safety/risk management respondents. Therefore it can be concluded that many people within the fire industry find the code difficult to follow. This problem may have already been recognised as earlier this year, BSI Global published a handbook for the use of BS 9999 (Green and Joinson, 2010). Half the respondents stated that they favoured BS 9999 over other current design codes but, of the respondents who use the code less often, not all of them think that the code is too complicated so there doesn't appear to be a clear link between finding the code complicated and using it less often.

The majority of respondents stated that they still saw or used non code compliant areas within buildings designed to BS 9999. The majority also believed that BS 9999 did not impact on the scope for fire engineers - only three respondents thought that it would reduce fire engineering practice. A small number said that it had changed their methods of working for the better, all of whom stated that it helped them justify their own fire engineering decisions as the decisions they would have made were now in a published code and thus allowed them to "support a case for alternative solutions".

Opinion was split on whether BS 9999 offered a more cost effective method of design over previous design codes with eight experts believing that it offered no extra cost benefits. Again, this was from the broad range of experts so there is no one "field" of fire engineering/design that thought that it didn't offer cost benefits.

4. Conclusion

The questionnaire given to experts in the field of fire engineering and other related areas has raised some interesting issues and identified further avenues for future work.

The intention at the start of the project was to look at the cost benefits of using passive protection in buildings. After this questionnaire, it can be seen that the respondents recognise the benefits of using a tool to be able to identify the most cost effective method of design. This will form the next stage of the research where a tool will be developed using data from actual fires in the UK to support statistical analysis in the program. Showing the costs and benefits of installing extra fire passive fire protection, over and above that required by the codes, might show experts that extra protection is worth a higher initial cost. More importantly showing the client that there are cost savings to be gained with a higher initial cost would prove beneficial to all involved.

The questionnaire has raised interesting points in terms of BS 9999 - not everyone believes that it offers a more cost effective method of design over previous codes and not everyone is using it yet. However, proof that the method is a cost effective method of design may persuade more people to use the building code over the others available. A comparison between the previous design codes and the now current, BS 9999 would probably show that the newer codes offer a better value for money when compared in similar buildings.

Further work needs to be in terms of making the conclusions more accurate – this will be achieved through more in depth interviews with members of the industry, especially fire engineers.

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