Department for Communities and Local Government Project Final Work Stream report:

BD 2887

Compartment sizes, resistance to fire and fire safety project

Work stream 3 – Construction details – roof voids, cavity barriers and fire/smoke dampers

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Prepared for:

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FIRE

BD 2887

Compartment sizes, resistance to fire and fire safety project

Final Work Stream Report for Work Stream 3 Construction details – roof voids, cavity barriers and fire/smoke dampers

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Executive Summary

Building Regulations Division, Department for Communities and Local Government (DCLG) commissioned BRE to carry out a project titled "Compartment sizes, resistance to fire and fire safety". The main aim of this project was to produce robust evidence and data based on research, experimental fire testing, computer modelling and laboratory testing, where necessary, on a number of linked work streams in relation to fire safety and associated provisions in Schedule 1 of Part B of the Building Regulations 2010.

This Final work stream report describes the findings of the research for Work stream 1 – Periods of fire resistance. The aim of this work stream was to produce robust evidence and data to explore the potential to develop improved publishable guidance in relation to compartmentation in roof voids and cavities and the performance of fire and smoke dampers.

This has been achieved through a review of current practice in these areas, a review of information derived from fire investigations and related research and a demonstration fire experiment providing new information on compartmentation in roof voids.

This work stream has also involved the participation of an industry Steering Group.

The research has concluded that when designed and installed in accordance with the provisions of the existing guidance in Approved Document B, fire protection systems are capable of achieving the requisite performance. The biggest issues influencing performance in the event of a fire are those of specifying the appropriate system, ensuring installation and maintenance is undertaken in accordance with manufacturer's instructions, and ensuring adequate supervision of any activities with the potential to damage, displace or compromise fire protection systems both during construction and over the lifetime of the building.

To this end, publishable guidance has been prepared as the major output from this work stream to identify the issues and provide information and references to assist those involved in the specification, installation and maintenance of fire protection systems within concealed spaces.

The general conclusions from this work stream are:

- The largest single issue with regard to the fire protection of concealed spaces remains that of quality of construction. The research presented here and supported by information from real fire incidents and related research projects shows that poor workmanship with inappropriate materials are the main reasons for the inadequate protection of concealed spaces.
- There is a clear and demonstrable need to ensure that buildings are designed and constructed so that the unseen spread of fire and smoke within concealed spaces within the structure and fabric is inhibited, as required by the Regulations.
- There is adequate guidance available in the public domain to allow this requirement to be achieved.
- A number of independent third party certification schemes exist to seek to ensure that the products used, and the installation of these products, is carried out effectively so that the fire protection system can perform as intended.
- It is important that follow on trades are aware of the importance of fire stopping and cavity barriers. If not, then the effectiveness may be compromised by later work carried out by persons

other than those installing the fire stopping or cavity barriers. This could negate any benefit from the original installation regardless of whether third party approved products and installers are used.

- The fire safety information required under Part B Regulation 38 is of proven value to those carrying out a fire risk assessment (under the Fire Safety Order), in particular with respect to the identification of concealed spaces. It is important that this information is made available when required.
- The publishable guidance document has particularly referenced the need for buildings to be designed and constructed so that the unseen spread of fire and smoke within concealed spaces in its structure and fabric is inhibited.
- The demonstration fire undertaken as part of the experimental programme for this work stream has demonstrated the ability of commonly used construction details to maintain compartmentation within a roof void in a realistic fire scenario.

Contents

1 Introduction and Objectives

This Final Work stream Report is delivered as part of the Department for Communities and Local Government (DCLG) project BD 2887, titled "Compartment sizes, resistance to fire and fire safety", DCLG Contract reference CPD/04/102/010. The main aim of this project was to produce robust evidence and data based on research, experimental fire testing (large and small scale), computer modelling and laboratory testing (where necessary) on a number of linked work streams in relation to fire safety and associated provisions in Schedule 1 of Part B of the Building Regulations 2010. The project was broken down into specific work streams.

This report describes the findings of the research for Work stream 3 – Construction details – roof voids, cavity barriers and fire/smoke dampers.

Experience from real fire incidents and related investigations suggests that the performance of some modern buildings in relation to the provisions of fire barriers in roof voids and wall cavities is not as effective as intended.

In 2010, DCLG published a research study on fire compartmentation in roof voids[1]. This found that information submitted for building regulations approval was often inadequate. It was also found to be common practice within the industry for only limited details to be included within the building regulations application. This puts the onus on the contractor to ensure the correct detailing which increases the risks of errors and omissions.

Similar concerns have arisen about the design of cavity barriers in wall cavities. These are often found to be missing or incomplete or incorrectly positioned. There is a growing consensus amongst experts that this is, to some extent, because the products commonly used for this purpose are not sufficiently robust or "builder proof". Whilst these concerns have not been disputed by manufacturers there are no drivers to encourage more effective solutions to be developed.

The principal objectives of this work stream were to:

- Produce robust evidence and data to explore the potential to develop improved publishable guidance in relation to compartmentation in roof voids and cavities and the performance of fire and smoke dampers

- Explore the potential to develop publishable guidance, explore alternative options other than detailed in AD B and consider the costs and benefits associated with any proposed changes.

A separate guidance document has been produced for this work stream. The guidance document contains more detail on the individual tasks undertaken as part of this work stream. This report should be read in conjunction with the publishable guidance document.

The Work stream 3 Tasks were:

- Task 3.1 Identification and engagement of stakeholders
- Task 3.2 Review of current practice in relation to compartmentation in roof voids, cavity barriers and fire and smoke dampers and ducts
- Task 3.3 Review of evidence from fire investigations

- Task 3.4 Review of large and small scale fire experiments
- Task 3.5 Experimental programme
- Task 3.6 Data analysis, cost benefit analysis and development of new guidance
- Task 3.7 Reporting.

2 Programme of work

2.1 Stakeholder engagement

This work stream has involved the participation of an industry Steering Group, Satellite Steering Group A. This group provided input during the course of the work, giving feedback on the research methodology as well as key deliverables and milestones. This group met three times.

The organisations represented at the Steering Group are as follows.

Organisations represented at the Steering Group
• Building Regulations Division, Department for Communities and Local Government (DCLG) • BRE Project team • British Constructional Steelwork Association (BCSA) • Association of Specialist Fire Protection (ASFP) • Association of Building Engineers (ABE) • British Automatic Fire Sprinkler Association (BAFSA) • Business Sprinkler Alliance (BSA) • Chief Fire Officers Association (CFOA) • The Chartered Institute of Building (CIOB) • The Concrete Centre • Fire Brigades Union (FBU) • Fire Industry Association (FIA) • Institution of Fire Engineers (IFE) • LABC • National Register of Access Consultants (NRAC) • Passive Fire Protection Federation (PFPF) • RICS Building Control Professional Group (RICS) • RISCAuthority • Scottish Building Standards (SBS) • Shore Engineering • Structural Timber Association (STA) • Warwickshire FRS • Welsh Government (WG)

During the course of the Satellite Steering Group A meetings, the issue of the installation of fire stopping and cavity barriers being correct at the time of installation but compromised by follow on trades was raised. Quality control on site is required to ensure that lack of understanding from other trades does not compromise the performance of fire stopping or cavity barriers.

A number of independent third party certification schemes exist to seek to ensure that the products used, and the installation of these products, is carried out effectively so that the fire protection system can perform as intended.

2.2 Review of current practice in relation to compartmentation in roof voids, cavity barriers and fire and smoke dampers and ducts

Findings indicate that current regulatory guidance in relation to compartmentation in roof voids, cavity barriers and fire resisting ducts and dampers if correctly adhered to, is capable of achieving the requisite performance. However, the review has highlighted the critical influence that workmanship plays in these areas and the important role that independent third party certification schemes can play in ensuring consistency of performance.

For roof voids, the principal output from the CLG research study, 'Compartmentation in roof voids' BD 2846[1] has been reviewed to establish current practice in this area. The review concluded, based on a number of real fire incidents, that where the compartmentation was designed and installed in line with the recommendations of AD B, it succeeded in preventing fire spread. However, a review of Building Regulations applications indicated that there is often insufficient detail presented during the planning phase to allow building control authorities to confirm compliance and the completed compartmentation is often not inspected during construction.

For compartmentation in roof voids four mechanisms of fire spread were identified:

- Combustible materials spanning beneath the non-combustible roof covering,
- Absent or poor installation of cavity barriers/compartmentation,
- Fire spread along the soffit and
- Heat transfer through penetrations.

For cavity barriers, the recently completed BRE Trust/NHBC Foundation research project into cavities in external wall constructions incorporating combustible material as a lining to the cavity[2], has demonstrated that all commonly used types of cavity barrier are capable of inhibiting the spread of fire for a reasonable period when specified correctly and installed in accordance with the manufacturer's instructions. However, the large-scale fire tests undertaken as part of the BRE Trust/NHBC Foundation project have shown that the performance of a number of commonly used types of cavity barrier are compromised if any gaps are present or the assumed level of compression of the barrier within the cavity is not provided. Of particular note, is the impact of cavity width on the performance of solid timber battens used as horizontal cavity barriers in the external walls of timber framed buildings.

As with compartmentation in roof voids and the installation of cavity barriers, workmanship can have a major impact on the performance of fire resisting ducts and dampers. Recent guidance[3] has highlighted the important role of independent third party accreditation schemes in ensuring that the product is capable of achieving the requisite performance in the event of a fire and that the level of performance is not compromised by problems with the method of fixing and installation.

2.3 Review of evidence from fire investigations

A review of 106 BRE fire investigations in the period 2003 to 2013 revealed 34 fires relating to Work stream 3. Of these 34 fires:

- 11 fires were solely related to compartmentation in roof voids.
- 10 fires were solely related to issues with cavity barriers.
- Six of the 34 fires combined issues with compartmentation in roof voids and cavity barriers.
- Four fires were related to fires in or issues involving ducting.
- One fire was related to ducting and compartmentation in roof voids.
- One fire was related to ducting and cavity barriers.
- The remaining fire was a potential issue surrounding cavity barriers. However, the fire was on a balcony and therefore cavity barriers were not required according to recommendations in Approved Document B.

The main issues of note were:

- There were seven cases where the junctions of the compartment wall with the roof were either not fire stopped or the fire stopping was inadequate and not continued to the roof.
- There were three cases where 'push-fit' cavity barriers were installed but moved after construction was completed or were poorly fitted in the first place.
- Twenty of the 34 cases involved inadequate cavity barriers; this includes absence of cavity barriers and poorly fitted cavity barriers.
- There were two cases where ducts passing through compartment walls were not fire stopped.
- There were five cases of the 34 where mineral wool in wire netting was used as a cavity barrier in a roof space but was shown to be inadequate mostly due to holes in the barriers.
- There were three cases where compartmentation in roof voids was effective and prevented fire spread throughout the void.

A number of additional case studies are included in the publishable guidance document based on fire investigations highlighting issues relevant to compartmentation in roof voids, cavity barriers and fire-rated ducts and dampers.

2.4 Review of large and small scale fire experiments

A number of previous research projects incorporating large and small scale fire experiments have been reviewed and the results incorporated into the guidance document produced as the principal output from this work stream. These projects include the TF2000 cavity fire incident and subsequent research into fire risks in combustible cavities[4], the BRE Trust/NHBC Foundation project into fires in cavities in residential buildings[2], and previous research projects providing input into a review of the guidance in Approved

Document B covering cavity barriers[5] and fire rated ducts and dampers[6]. The review found no evidence of large or small scale fire experiments dealing with the issue of compartmentation in roof voids. Further details on related research may be found in the publishable guidance document produced for this work stream.

2.5 Experimental programme

Experiment 7, the final experiment for the Compartment sizes, resistance to fire and fire safety project involved the construction of a compartment wall within the roof space formed from a truss rafter roof built over the existing compartment experimental rig. The experiment demonstrated the ability of a particular specification of compartment wall within a roof structure to provide the requisite performance in the event of a fire spreading into the roof space. In this instance, the detail was a timber frame spandrel panel representing the continuation of a compartment wall into the roof space. The performance of the system is dependent on the fire stopping between the compartment wall and the roof membrane and on insulation between the battens used to fix the tiles. The fire stopping in these areas was in accordance with guidance provided in Approved Document B and details set out in guidance published by the NHBC[7].

The roof fire experiment differed from the previous six experiments in that this was primarily a demonstration of performance rather than an attempt to generate fundamental data for subsequent analysis. The initial condition consisted of a compartment lined on the walls and ceiling with two layers of fire rated plasterboard. The trussed rafter roof was built on top of the existing floor screed over a beam and block floor from rafters provided by the Truss Rafter Association (see Figure 1).

Figure 1 - Trussed rafters used for compartmentation in roof voids experiment

The gable ends and the intermediate compartmentation within the roof space were formed from spandrel panels (see Figure 2) constructed to a specification prepared by the Structural Timber Association.

Figure 2 - Timber used to form spandrel panels

The gable end spandrel panels were protected with two layers of fire rated plasterboard on the internal face only (see Figure 3) while the intermediate spandrel panel forming the internal compartmentation within the roof space was protected with two layers of 12.5mm fire rated plasterboard on either side (see Figure 4).

Figure 3 - (Northern) Gable end showing plasterboard to internal face of spandrel panel

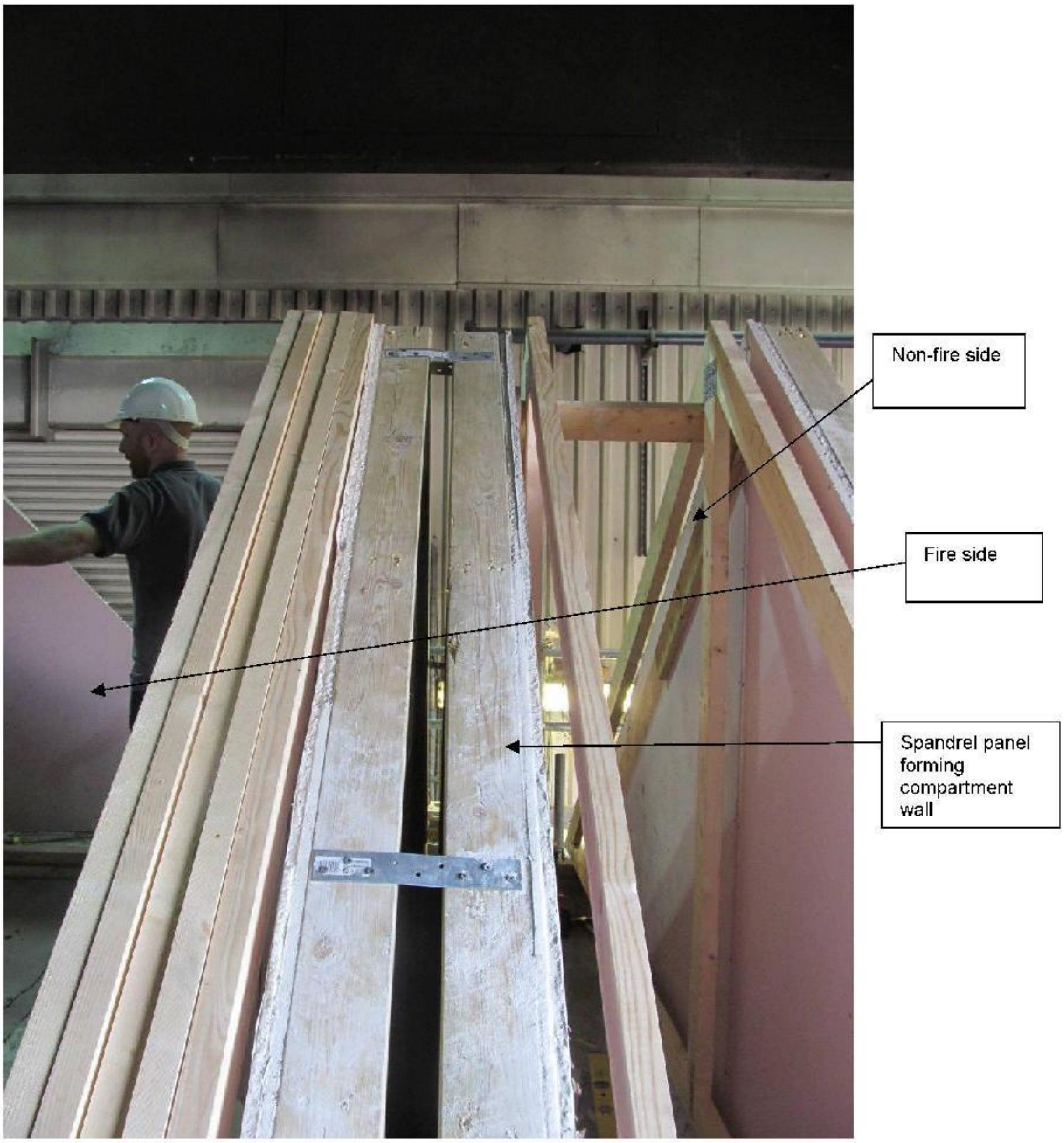

Figure 4 - Intermediate spandrel panel showing double layer plasterboard protection

The spandrel panels were cut approximately 25mm below the level of the trusses and the gap between the top of the panel and the roofing membrane was filled with a 30mm thick rock fibre slab (RWA45 grade material) as specified through the ASFP and supplied through the Structural Timber Association. The same insulation was used to cover the space between the tile battens to fill the gap between the roofing membrane and the clay tiles (see Figure 5). The battens were continuous over the spandrel panel.

Figure 5 - Insulation between tiling battens prior to fixing roof tiles

Four 60mm diameter holes were drilled through the ceiling towards the centre of the compartment and the plasterboard at this point locally weakened by a saw cut (see Figure 6) to provide a means by which the fire could enter the roof space without subjecting the roof to the immediate effects of a fully developed post-flashover fire.

Figure 6 - Holes drilled through plasterboard in centre of fire compartment (The finished roof with the location of the intermediate spandrel panel indicated by yellow paint is shown in Figure 7)

Figure 7 - Completed roof structure with spandrel panel location indicated by yellow paint

The key observations from the roof fire experiment are summarised in Table 1.

Approximate time from ignition (min: sec)	Observation
0:00	Ignition
1:20	Board fitted over horizontal opening following ignition
7:00	Flashover (external flaming and compartment temperatures > 500°C)
40:00	Compartment fire extinguished
80:00	Additional fuel put into compartment
90:00	Roof collapse

Table 1 - Key observations from roof fire test

The key events are highlighted in the graphs showing compartment temperatures and temperatures within the roof space either side of the compartment wall (see Figures 8 and 9).

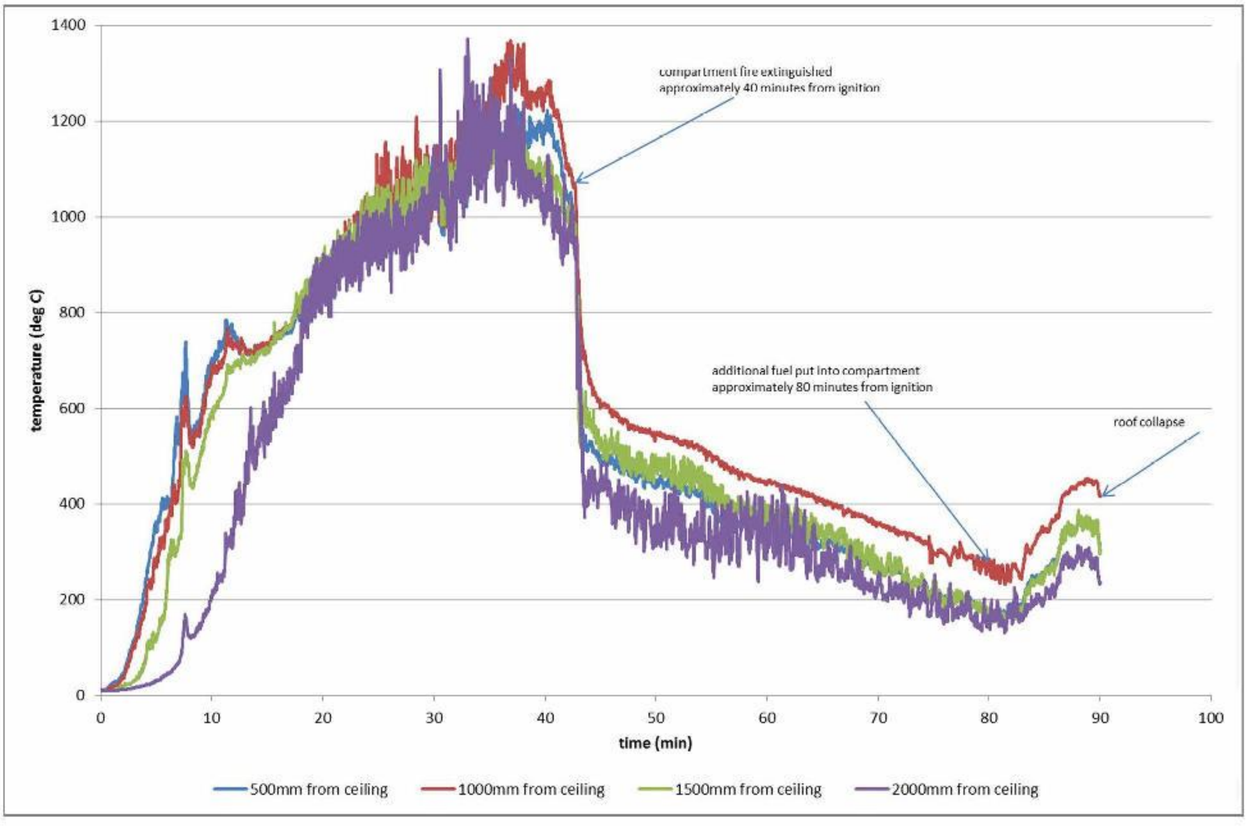

Figure 8 - Compartment temperatures (North West corner)

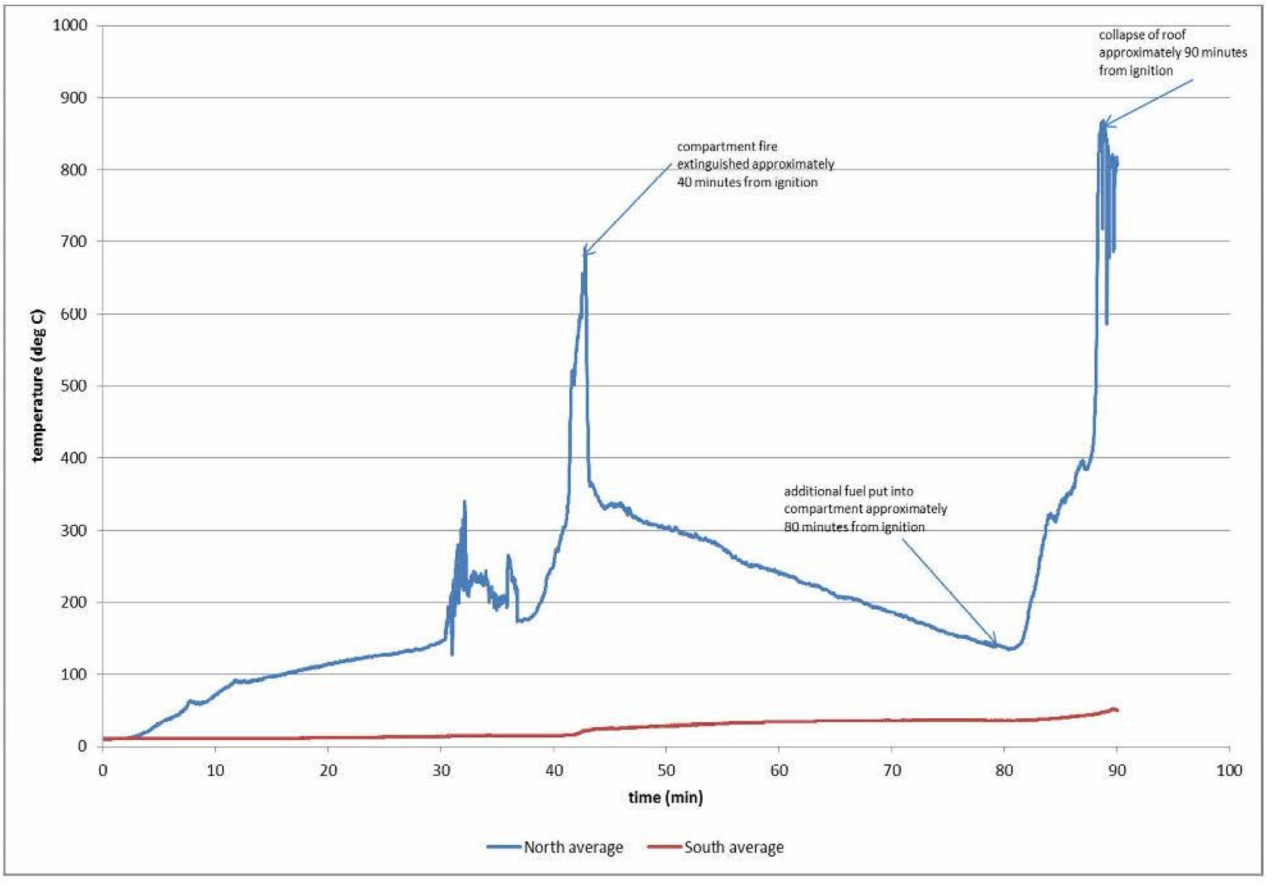

Figure 9 - Average temperatures in roof void either side of compartment wall

The results clearly indicate that the compartmentation has prevented any significant rise in temperature on the non-fire side of the roof space. The performance was clearly borne out through observations with the spandrel panel remaining intact despite a collapse of the roof structure on the fire side (see Figure 10).

Figure 10 - Collapse of roof structure with compartmentation intact

Full details of the experiment are provided in the publishable guidance document produced as the major output for this work stream.

2.6 Data analysis, cost benefit analysis and development of new guidance

A review of existing information in relation to compartmentation in roof voids, cavity barriers and fire-rated ducts and dampers has been undertaken for this work stream. Evidence from real fires has been reviewed to establish mechanisms of fire spread and potential modes of failure. Based on the review of information, a large scale fire experiment has been conducted to demonstrate performance of a specific design solution in a realistic fire scenario in relation to compartmentation in roof voids. A comprehensive guidance document has been produced to bring together the important information derived over the course of the project.

There are no recommendations to make any specific changes to the regulatory guidance and therefore a cost benefit analysis is not appropriate for this particular work stream.

3 Conclusions

The increasing use of innovative construction methods (modern methods of construction), materials, and building design (often in response to the need for energy efficiency) is resulting in an increase in concealed voids and an increase in combustible material within these voids.

The fire protection of concealed spaces is of prime importance because any deficiencies in installation and materials are not readily apparent and may quickly be covered over by following trades. Any inadequacies in such fire protection cannot be seen by the building users and, unlike other engineering provisions within the building, will not be apparent during everyday use. Any inadequacies in the fire protection of concealed spaces will only become apparent during a fire.

The general conclusions from this work stream are:

- The largest single issue with regard to the fire protection of concealed spaces remains that of quality of construction. The research presented here and supported by information from real fire incidents and related research projects shows that poor workmanship with inappropriate materials are the main reasons for the inadequate protection of concealed spaces.
- There is a clear and demonstrable need to ensure that buildings are designed and constructed so that the unseen spread of fire and smoke within concealed spaces within the structure and fabric is inhibited, as required by the Regulations.
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- The fire safety information required under Part B Regulation 38 is of proven value to those carrying out a fire risk assessment (under the Fire Safety Order), in particular with respect to the identification of concealed spaces. It is important that this information is made available when required.

4 Acknowledgements

The authors, Tom Lennon, Ciara Holland and Martin Shipp, would particularly like to acknowledge the valuable contribution provided by the following:

- Satellite Steering Group A and the overall Project Steering Group.
- BRE colleagues: Richard Chitty and Corinne Williams.
- BRE project team members: Luke Bisby, University of Edinburgh and Neal Butterworth, Arup Fire.
- BRE experimental team for Experiment 7: Tom Lennon, Phil Clark, Darran Draper, Harry Granados.
- Steering Group member companies who contributed materials for BRE experiment 7: Beam and block floor and blocks for walls were supplied through the Concrete Centre, RWA45 grade material as specified through the ASFP and supplied through the Structural Timber Association, rafters provided by the Truss Rafter Association.
- Steering Group members who provided specialist advice in relation to the construction of the experimental rig.

5 References

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7. NHBC Design Standards Part 7 Roofs – Chapter 7.2 Pitched roofs, NHBC, Milton Keynes, Effective from 1 January 2012.

Appendix A – Summary of the Research

Building Regulations Division, Department for Communities and Local Government (DCLG) commissioned BRE to carry out a project titled "Compartment sizes, resistance to fire and fire safety". The main aim of this project was to produce robust evidence and data based on research, experimental fire testing, computer modelling and laboratory testing, where necessary, on a number of linked work streams in relation to fire safety and associated provisions in Schedule 1 of Part B of the Building Regulations 2010.

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