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Fire in timber frame buildings
A review of fire statistics from the UK and the USA

RISCAuthority

administered by FPA Fire Protection Association

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SUMMARY

This document has been produced at the request of RISCAuthority members in response to a noted change in UK claims experience in respect of lightweight timber frame (LTF) buildings both in-construction and once completed and occupied. The report seeks to explore the impact that lightweight timber frame buildings might have in the UK, as a future dominant building method, based upon current UK statistics and historic US experience.

LTF initiatives have previously gained prominence in the UK at times of intense housing need; following wars and more recently in the 1980s, before being discredited in England and Wales following a *World in Action* television documentary, though its use still persisted in Scotland.

When comparing UK and US statistics it is critical to bear in mind that the controls in place to limit the size of LTF buildings in the USA are considerably more stringent than in the UK, particularly when not protected by a sprinkler system:

LTF building restriction	USA	UK
Unsprinklered height	40ft (typically three floors)	No restriction
Maximum area before significant structural firewall required	2000m^2	No restriction
Sprinklers mandated	All multiple occupancy dwellings	Not mandated

The US limitations were deemed necessary in the name of fire safety. In fact, recent tightening of the USA's sprinkler legislation will mean that not only will all multiple occupancy dwellings require sprinkler protection, but so will all new build single occupancy houses, following changes to the building codes adopted by 48 states, which was due to come into effect in January 2011. As such, the US experience may generally describe a lesser potential for loss than might be expected to unfold in the UK, given its lack of controls and restrictions although differences in US building design detail must also be considered.

To fully appreciate the statistics described, estimates have been made for timber frame building stock as a percentage of the total building population. This is not a simple calculation to perform since no single body appears to hold this information. Our best estimate of lightweight timber frame dwellings is:

- 1.7% in England;
- 1.5% in Wales;
- 9.9% in Scotland; and
- 90% in the United States.

CLG's recently released **Fire Statistics Monitor – April 2009 to March 2010. Issue No 03/10** confirmed the insurer experience that damage in LTF builds was disproportionately more than for conventional build methods. What the report did not detail was that, subject to the accuracy of the LTF building market share estimates, a fire is apparently more than twice as likely to occur in a LTF building. Whilst this might be down to the nature of risks being housed in LTF buildings, an alternative view might be that for a constant fire ignition likelihood across all building types, disproportionately more manifest as an official fire in LTF buildings – ie they are able to become big enough to warrant fire and rescue service intervention, where they might otherwise die out or be tackled at source in other forms of construction. Clearly, if this is the case then it might not be unreasonable to assume that there is a need for government to consider these findings in the context of its life-safety responsibilities.

In spite of the maturity of the US timber frame experience, and the fire safety controls described:

- unprotected wood frame buildings **under construction** are the most frequent large loss fires in the US (over $5-10 million);
- fires in unprotected wood frame residential buildings are the third most frequent **large loss fires** in the US;
- fires in unprotected wood frame buildings account for the most firefighter injuries in the US;
- within the US, unprotected wood frame construction dataset, fires in residential buildings accounted for the most firefighter injuries;
- fires in unprotected wood frame buildings account for over half of all fires that result in catastrophic multiple fire deaths in the US;
- fires in unprotected wood frame buildings account for over half of all fire fatalities in the US; and
- it is estimated that, on average, for every 100,000 populace, there are 1.10 fire related deaths in the home in the US compared to 0.63 currently in the UK.

From an insurance perspective, it is very interesting to note that the number of dwelling fires in England and Wales as a percentage of all building fires, compared with the US, is very similar: 71% versus 76%. Where stark differences occur is in the associated financial loss. In England and Wales, these fires account for 35% of the total financial loss attributable to fire, whereas in the US it is 71% – a figure that may be relevant when considered against the 1.9% to 90% LTF domestic housing stock difference.

Scrutinising this point further, dwelling fires that require fire and rescue service intervention are significantly more prevalent in the United States and Scotland, where there is higher LTF building use, than in England and Wales.

RECOMMENDATIONS

On the basis of this work RISCAuthority makes the following recommendations:

- There is a need to revisit and review the impact analysis and associated research made by CLG in support of the introduction of LTF construction as a potential future dominant building method in the context of the recent UK and historic US experience.
- There is a need to review **Approved Document B** (**ADB**) and the associated inspection process in the context of the recent UK and historical US experience. We believe we are moving to a very different built environment where the demands on **ADB** are likewise very different. When building out of bricks and mortar and other non-combustible materials, the resulting building may be quite *tolerant* of minor deviations and imperfect build. **ADB** has been developed largely in the context of non-combustible building methods and materials and this may explain its looseness and lax accompanying inspection. LTF and other MMC building methods involving combustible materials can be *highly intolerant* to any deviation in design, construction and alteration, and **ADB** needs to

respond to this to ensure the fire safety ambition is achieved and maintained at completion and has a high likelihood of being maintained over the life of the building. Whilst this report focuses on unprotected LTF buildings, US data for all categories of construction has been analysed, and when assessing sprinkler-protected buildings, the differences are remarkable.

- There is a need to look forward to a time when considerable densities of LTF and other MMC building methods involving combustible materials become prevalent within our major cities and consider whether there might be a need to consider 'collective' fire safety of building groupings more thoroughly and review building separation distances and the adequacy of fire and rescue services' resources for dealing with larger events (possibly involving multiple buildings) in confined city and town surroundings.
- There is a need for extensive instruction, training and guidance to ensure the correct build and sympathetic occupation of LTF and MMC buildings which include combustible materials. This information needs to be readily available and digestible by all who form or break the plasterboard fire compartment boundaries, including constructors, follow-on trades, service installers, owners and occupiers. Guidance from the Electrical Safety Council suggests that any modification of the party wall between properties in LTF buildings that requires making holes in the lining or the installation of plastic accessories might constitute a 'notifiable activity' under the Party Wall Act (England and Wales), or require a building warrant (Scotland). They therefore advise notifying neighbours of intended works to give them the opportunity to object to, comment upon, or prevent the work taking place. Any structural alteration which does not adhere to legal regulations may for the property owner/occupier have insurance implications in the event of a loss.
- There is a need for fire and rescue services to plan for very large construction site fires and have tools and training to manage cavity fires in multi-storey apartment blocks. If the situation in the UK unfolds to follow the US experience, but devoid of US constraints on LTF building size (and other) restrictions, then there may be a need to gear up to provide for speedier, weightier and more numerous response to fires with greater life safety threat. A review of evacuation policies for multi-storey buildings is recommended particularly in terms of stay-put methods and the location of those less able to help themselves.
- The UK insurance industry needs to have in place a mechanism to collect and analyse loss data, appropriately categorised by construction method, so that it may respond accordingly if, as, and when changes in the built environment manifest positively or negatively on insurance claims. Significant new risks should be surveyed for conformity, and significant losses should be forensically investigated to see if poor quality build, or later adjustment, or inefficient fire and rescue service response contributed to the scale of loss.

1. Working Fire (2010) Structural Fire Spread [Online] Available: http://www.workingfire.net/misc7.htm [11/11/2010].

1. INTRODUCTION

This document has been produced at the request of RISCAuthority members in response to a noted change in UK claims experience in respect of lightweight timber frame (LTF) buildings both in-construction and once completed and occupied. The report seeks to explore the impact that lightweight timber frame buildings might have in the UK, as a future dominant building method, based upon current UK statistics and historic US experience. Dominant sources of information for the UK are the Communities and Local Government, (2010) Fire Statistics Monitor – April 2009 to March 2010. Issue No. 03/10; and for the US the NFPA annual fire statistics reviews.

2. DEFINITIONS

All definitions are valid throughout this document, except where explicitly stated otherwise.

Dwelling

Refers to all housing used for permanent occupation (excluding university accommodation).

Residential

Refers to all buildings which might be used as accommodation, including housing, hotels and motels as well as university and college accommodation.

Protected

Protected buildings are buildings with sprinkler systems installed.

Unprotected

Unprotected buildings have no sprinkler system installed.

No special construction

Refers to buildings constructed using traditional building materials and construction techniques.

The five basic construction types used in the United States are arranged in a scale based on the amount of combustible material used in their construction. For example, a Type I fire-resistive building has the least amount of combustible material in its structure; a type V wood frame building has the most.[1]

Non-combustible (Type I & II)

Buildings utilising steel and concrete for the walls, floors and structural framework.

Ordinary (Type III)

Also known as brick and joist structures. Utilises masonry bearing walls, but the floors, structural framework and roof are made from wood and other combustible materials.

Heavy timber (Type IV)

Buildings utilising masonry walls, but the interior wood consists of large timbers. The floor and roof are of plank board. In heavy timber construction, a wood column cannot be less than eight inches thick in any dimension and a wood girder cannot be less than six inches thick. Unlike ordinary construction, the wood structure is not covered in plaster and is therefore left exposed.

Wood frame (Type V)

Refers to modern methods of light timber construction that commonly utilise platform building techniques, where the interior framing and exterior walls are made from wood (also referred to in this report as timber frame and light timber frame or LTF). In the UK, most timber frame buildings utilise a brick slip as exterior cladding.

3. THE LIGHT TIMBER FRAME ISSUE

It is important that the distinction is made between LTF builds, as described below, and more traditional methods of heavy timber frame construction, typified through the use of hardwoods such as oak, which fall into a different building classification and are governed by separate fire safety regulations.[2]

3.1 Light timber frame construction

Light timber frame construction methods have become the dominant form of construction in North America as well as many other nations across the world. Whilst so called 'balloon' framing techniques found favour in the early 1900s, most modern methods are based on 'platform' techniques.

This construction methodology relies on consistently sized and spaced timber. When using a platform system the walls and ceiling of any particular storey rely on the floor below for support, with no structural members running the height of a building as in balloon construction. Torsional strength is provided through the use of plywood or composite wood sheathing attached to the timber members.

Platform framing techniques have become ubiquitous as they provide a modular approach to LTF building that is readily adaptable for use in prefabricated builds.

In addition to this, LTF builds are seen as the sustainable alternative to more traditional building materials, with reputed build time and cost savings.

3.2 Light timber frame construction in the USA

The United States has a long history of timber frame construction. Plentiful supply of timber, rapid erection, prefabrication and modular construction as well as the ability to mass produce have all contributed to ensure timber frame has remained the construction technique of choice in North America. Thus the housing stock in United States is saturated with LTF buildings.

The first changes to regulations governing LTF buildings in the United States were not unified. Some states or municipalities adopted amended versions of the model code mandated by the government. All of these model codes recognised limitations on timber frame building height and area. However, they also acknowledged various factors that could change these values, such as building use and safety features.[3]

These regulatory changes have been largely led by market forces, with building developers looking to offset rising land prices by increasing project density, particularly in urban areas. Although many factors contribute to limitations on multi-storey timber frame builds, such as structural load considerations, cumulative effects of wood shrinkage and sound transmission, the limiting factors of building height and area are still dictated by fire safety considerations.[4]

In 2000, the first International Building Code was published, and has now been adopted by all 50 states. The code limits all unprotected residential timber frame buildings to a maximum of three storeys and a height of 40 feet. Implementing an approved automatic sprinkler system can increase these limits to four storeys and a height of 60 feet.

The building plan area per storey for timber frame buildings has a maximum of 12,000ft^2, around half the nominal value for other construction methods. However, fire walls can be used to segment a structure into multiple buildings for determining allowable floor areas.[5]

3.3 Light timber frame construction in the UK

The use of timber framing in the UK has fallen in and out of fashion. During periods of high demand and of skills shortages, particularly acute during the world wars and later in the '60s, timber frame construction was common.[6]

Bad publicity during the '80s spurred a dramatic downturn in the use of timber frame building in the UK, thought to be triggered by a *World in Action* exposé, showing examples of poor site practice and recurrent defects found on timber frame builds.[7]

The subsequent downturn predominantly affected England and Wales, where governments and private developers stopped funding timber frame projects.[8]

Driven by the need to provide more sustainable and affordable housing during the '90s, building regulations in the UK were changed to make it possible to construct up to eight storeys in timber frame, without loss of economy from excessive fire protection requirements.[9]

3.4 TF2000 project

The British Government, in partnership with BRE and the timber industry, took the initiative in setting up the TF2000 project in 1995. This venture was intended to benchmark the performance of multi-storey timber frame buildings and thus provide assurances to the building community about the safety of this newly mandated type of construction.

The tests also provided an opportunity to incorporate and assess many new developments in construction techniques, particularly improvements in prefabrication, commonly referred to as modern methods of construction[10] (MMC) with a view to providing more comprehensive design guidance for medium sized timber frame buildings.

3.5 TF2000 controversy

Much controversy surrounds the TF2000 tests. Whilst the building passed all the specific fire safety tests undertaken, an

2. Technical Services Information Bureau (2008) Technical Bulletin [Online] Available: http://www.tsib.org/pdf/technical/10-101_Building_Codes.pdf [28/10/2010].
3. Timber Design (Unknown) Multi-Story Wood Frame Construction in the United States [Online] Available: http://www.timberdesign.org.nz/files/Multi-Storey%20Wood%20Frame%20Construction%20in%20the%20US.pdf [27/10/2010].
4. International Council on Monuments and Sites (2000) Multi-Story Wood-Frame Construction [Online] Available: http://www.icomos.org/iiwc/seismic/Cheung-K.pdf [27/10/2010].
5. International Code Council (2010) IBC 2009 [Online] Available: http://www.iccsafe.org/Store/Pages/default.aspx [08/10/2010].
6. Parliamentary Office of Science and Technology (2003) Modern Methods of House Building [Online] Available: http://www.parliament.uk/documents/post/postpn209.pdf [28/10/2010].
7. Brand New Homes News Feature (2002) Fire Alarm [Online] Available: http://www.brand-newhomes.co.uk/Timber%20frame%20fire%20report%20Building%2019%20July%2002.pdf [27/10/2010].
8. Wood Knowledge Wales (2010) Timber Frame Construction [Online] Available: http://www.woodknowledgewales.co.uk/ [26/10/2010].
9. BRE Projects - TF2000 (2003) Reaching New Heights in Timber Frame Construction [Online] Available: http://projects.bre.co.uk/tf2000/index.html [26/10/2010].
10. MMC Centre (2010) Modern Methods of Construction [Online] Available: http://www.mmccentre.com/ [26/10/2010].

incident involving a cavity fire, which smouldered unnoticed after the 60-minutes' fire compartment test, resulted in damage to four storeys of the building.

Many parties see the exclusion of this information from the final TF2000 report as a betrayal of trust. Stakeholder groups involved in the report maintain that the information was irrelevant to the tests success.[11]

Nonetheless, the use of timber frame construction in the UK has seen a resurgence since 2000, with the market share of new builds growing dramatically.

3.6 Building Regulation of light timber frame buildings in the UK

Building regulations are often considered a barrier to performance, innovation and trade. Recent changes in the presentation of building regulations mean they are now performance-based rather than prescriptive, broadening the solutions available for compliance in any one situation.[12]

This has been heralded as a significant breakthrough for the increasing use of timber in multi-storey applications, as it provides a driver for innovation as well as the ability to make use of new building materials and construction techniques.[13]

However, there are issues surrounding the use of performance-based regulations.

In areas such as fire safety, performance targets are only set for individual systems and therefore do not clearly establish the whole performance expectation for a building. Therefore, the impact of a fire-related design decisions on another system is not quantifiable or controlled.[14]

This also means that fire design solutions can be justified using performance predictions, extrapolated from a limited number of stylised tests, with no evidence of how the whole building will behave in a real life scenario.

A glaring example of this failing is the TF2000 60-minutes' fire compartment test. As an isolated system, the fire compartment test was a success, and therefore satisfies its performance target. The fact that four of the six floors in the building were damaged following the test is dismissed as an irrelevance through the application of performance-based regulation, despite the building (as a combined system) clearly not functioning as intended.

11. RIBA Journal (2010) September Letters [Online] Available: http://www.ribajournal.com/index.php/feature/article/letters_september_2010/ [26/10/2010].

12. Performance Based Building Thematic Network (2005) Performance Based Building Regulations [Online] Available: http://www.pebbu.nl/resources/allreports/downloads/11_d7_finalreport.pdf [27/10/2010].

13. Timber Design (Unknown) Multi-Story Timber Buildings in the UK and Sweden [Online] Available: http://www.timberdesign.org.nz/files/MultiStorey%20timber%20building%20in%20UK%20and.pdf [27/10/2010].

14. IRCC Building Regulations (2003) Role of Acceptable Solutions in Evaluating Innovative Designs [Online] Available: http://www.irccbuildingregulations.org/pdf/Paper2-DenisBergeron-CIBKLConference-Codes_Standards.pdf [27/10/2010].

15. Chiltern International Fire (2003) Understanding Fire Risks in Combustible Cavities [Online] Available: http://www.chilternfire.co.uk/ [27/10/2010].

16. UK Timber Frame Association (2009) SiteSafe [Online] Available: http://www.uktfa.com/#/sitesafe/4538986474 [28/10/2010].

3.7 Quality control in the construction of light timber frame buildings in the UK

With fire safety in timber frame buildings being heavily reliant on high standards of workmanship, there are concerns that quality control is not being consistently applied or adequately policed, particularly in view of dramatic expansion in timber frame use.

Site inspections carried out as part of a report into cavity fires, discovered reoccurring problems with the installation of cavity barriers. A recommendation from the report cited the need to raise awareness in the construction industry of the consequences of poor standards of workmanship on timber frame builds as well as the need to ensure responsibility, and therefore liability, for the correct implementation of fire barriers and other fire precautions is maintained throughout a build.[15]

The problem of quality control in timber frame builds is highlighted by a recently filed lawsuit against a building contractor. In this case, an insurer is unwilling to pay for fire damage caused as a result of poor workmanship. This type of lawsuit may become common if these quality issues are not addressed.

3.8 Analysis of light timber frame building fires in the UK and the USA

There is currently a limited set of data sources that scrutinise the frequency, material damage and cost of fires in LTF builds – specifically, as a comparison with more traditional construction techniques.

There are many reasons for this, primarily because of the difficulty involved with collecting the data. In the UK, modern LTF builds are clad in brickwork to superficially resemble buildings of ordinary construction.

Fires in timber frame buildings under construction have already been recognised by the insurance community as a huge concern. The damage and cost of such fires is considerable and disproportionate.

Work is ongoing to reduce the occurrence of such fires through such schemes as SiteSafe, implemented by the UK Timber Frame Association[16], but this persistent problem is not easily solved.

Fires in completed LTF buildings are more difficult to analyse. In England, recent changes in the fire incident recording system have made it possible for the first time to separate fires in LTF buildings and those of ordinary construction.

Over time, this will become a valuable resource of information on types of building fires, however until a significant bed of evidence is collected, this data will only provide an indication of the current situation in England.

The situation in the United States is different. With LTF buildings having dominated the housing market for many decades, more data is available for a comparison. This can be used to highlight the contrast between the matured timber frame construction environment seen in the United States, with the emerging market of the UK.

This evidence may help predict the future of fire trends in the UK, if LTF buildings continue to expand market share in the coming years.

This report seeks to expand the understanding of fire trends in buildings of different constructions in the UK and the United States.

4. ESTIMATING RESIDENTIAL TIMBER FRAME MARKET SHARE IN GREAT BRITAIN AND THE UNITED STATES

4.1 Light timber frame dwelling market share in England, Wales and Scotland

Understanding the market share for LTF buildings in the UK is vital when analysing fires in buildings of different construction. This is a difficult figure to estimate. Through the summation of newly registered house builds each year and the percentage of which are timber frame, it is possible to estimate the total number of LTF dwellings built between 1998 and 2009, and thus the market share during this period.

It is estimated that in total during the 20th century, one million pre-fabricated buildings were built in the UK. Many of these buildings were designed as temporary accommodation.

It is estimated that a third of these pre-fabricated buildings were made using timber frame. Assuming all of these buildings were dwellings and are still in use, that accounts for approximately 333,000 timber frame houses.

With the total number of timber frame builds calculated between 1998-2009 reaching 320,000, it may be fair to assume that the timber frame percentage calculated in this period could be doubled to give a good estimation of total dwelling market share for LTF buildings.

This results in the estimates:

- 1.7% dwelling timber frame market share in England;
- 1.5% dwelling timber frame market share in Wales; and
- 9.9% dwelling timber frame market share in Scotland.

Consequently, the timber frame market share is estimated at 2.4% for the UK.

4.2 Light timber frame dwelling market share in the USA

In 2000, the timber frame market share of new dwellings in the United States was estimated to be in excess of 90%[17]. The construction of dwellings in the United States is saturated with LTF buildings and has been for many years.

This suggests that the value of 90% is likely to be characteristic of the whole timber frame market share for dwellings in the United States and will be used as a benchmark in this report.

4.3 Active fire suppression in dwellings

In the UK, the use of active fire suppression systems for domestic applications is extremely rare. The situation in the United States is different.

17. Simon Palmer on behalf of Sustainable Homes, (2000) Sustainable Homes: Timber Framed Building [Online], Available: http://www.sustainablehomes.co.uk/upload/publication/Timber%20Frame%20Housing.pdf [13/10/2010].

Table 1: Light Timber Frame Residential Market Share in England, Wales and Scotland (1998-2009)

	England				Wales				Scotland			
	Housing stock[a] (000s)	New dwellings (000s)	Timber frame (TF) % of new[b]	New TF	Housing stock[c] (000s)	New dwellings (000s)	Timber frame (TF) % of new	New TF	Housing stock[d] (000s)	New dwellings (000s)	Timber frame (TF) % of new	New TF
1998	20,778	155	(2%)	3,100	1,252	8.15	(3%)	245	2,283	17.0	(43%)	7,310
1999	20,928	150	(3%)	4,500	1,259	7.42	(6%)	445	2,303	20.0	(44%)	8,800
2000	21,075	147	(5%)	7,350	1,267	8.05	(6%)	483	2,313	10.0	(51%)	5,100
2001	21,208	133	(6%)	7,980	1,275	7.51	(9%)	676	2,322	9.0	(46%)	4,140
2002	21,338	130	(5%)	6,500	1,281	7.24	(6%)	434	2,331	9.2	(52%)	4,769
2003	21,482	144	(7%)	10,080	1,289	7.54	(9%)	678	2,348	17.8	(59%)	10,483
2004	21,635	153	(9%)	13,770	1,297	7.68	(13%)	999	2,368	19.3	(62%)	11,963
2005	21,805	170	(11%)	18,700	1,305	8.45	(11%)	930	2,389	20.3	(63%)	12,791
2006	21,992	187	(11%)	20,570	1,313	8.08	(12%)	969	2,408	19.6	(60%)	11,747
2007	22,190	198	(15%)	29,700	1,322	9.31	(12%)	1,117	2,430	21.9	(72%)	15,773
2008	22,398	208	(17%)	35,360	1,331	8.60	(16%)	1,375	2,452	21.6	(74%)	15,956
2009	**22,564**	166	(17%)	**29,880**	1,338	7.11	(26%)	**1,849**	2,469	16.9	(70%)	11,856
Total (000s)	–	1,941	–	187.5	–	95.1	–	10.2	–	202.5	-	120.6
TF % of new (since 1998)	–	–	**9.7%**	–	–	–	**10.7%**	–	–	–	**59.6%**	–
TF % of stock (since 1998)	–	–	**0.8%**	–	–	–	**0.8%**	–	–	–	**4.9%**	–

(a) Communities and Local Government (2010) Dwelling Stock Estimates [Online] Available: http://www.communities.gov.uk/publications/corporate/statistics/housingstock2009 [14/10/2010].
(b) NHBC (2010) New House Building Statistics [Online] Available: http://www.nhbc.co.uk/NewsandComment/UKnewhouse-buildingstatistics/ [14/10/2010].
(c) Ystadegau Ar Gyfer Cymru (2010) Dwelling Stock Estimates [Online] Available: http://wales.gov.uk/docs/statistics/2010/100401sdr502010en.pdf [14/10/2010].
(d) The Scottish Government (2010) Housing Statistics For Scotland [Online] Available: http://www.scotland.gov.uk/Topics/Statistics/Browse/Housing-Regeneration/HSfS/KeyInfoTables [14/10/2010].

The International Code Council (ICC) develops codes and standards used to construct residential and commercial buildings in the United States.[18]

In the 1980s, the ICC put in place the requirement for mandatory installation of sprinkler systems in multiple occupancy buildings. The ICC's Residential Building Code Committee (RBCC) recently voted to approve the inclusion of fire sprinklers as a standard feature in all new homes, to come into effect in January 2011.[19]

The market share for domestic sprinkler systems in the United States is hard to estimate.

Prior to 2008, it was estimated that no more than 3% of new single occupancy builds included sprinkler systems each year.[20] In 1998, it was calculated by the NFPA that sprinkler systems were present in 2.5% of all recorded residential building fires.[21]

Through evaluation of these figures, it is clear that sprinkler systems in residential buildings likely represent less than 5% of the total residential building stock in the United States. This is likely to rise dramatically in the following years given the recent changes to regulations, and it will be interesting to monitor the effect this has on domestic fires in the United States in the future.

Note: The analysis of active fire suppression for domestic applications has only been included for reference; when considering data in the report related to protected and unprotected buildings. It is understood that the method used to calculate this figure leaves a large margin for error.

18. International Code Council (2010) About ICC [Online] Available: http://www.iccsafe.org/AboutICC/Pages/default.aspx [04/11/2010].

19. International Residential Code (2010) Fire Sprinkler Coalition [Online] Available: http://www.ircfiresprinkler.org/IRCHistory.aspx [04/11/2010].

20. Residential Fire Sprinklers (2008) Market Growth and Labour Demand Analysis [Online] Available: http://www.residentialfiresprinklers.com/Residential_Fire_Sprinklers_Market_Analysis.pdf [04/11/2010].

21. Building Industry Association of Washington (2005) Residential Fire Sprinkler [Online] Available: http://www.biaw.com/documents/Residential_Fire_Sprinkler.pdf [04/11/2010].

22. Communities and Local Government, (2010) Fire Statistics Monitor – April 2009 to March 2010. Issue No. 03/10 [Online] Available: http://www.communities.gov.uk/publications/corporate/statistics/monitorq1q420091 [18/10/2010].

5. FIRE STATISTICS FOR ENGLAND

5.1 CLG Fire Statistics Monitor

The latest publication of the Communities and Local Government (CLG) **Fire Statistics Monitor**[22] has for the first time utilised changes in the Incident Recording System to include a separate analysis of fires related to timber frame buildings.

The analysis focuses on comparing the extent of heat damage between buildings identified as timber frame and those identified as being of no special construction. Table 2 below focuses on completed buildings, while Table 3 examines buildings under construction.

When dealing with completed buildings, it is to be expected that the type of construction used may not be immediately apparent. This problem is particularly acute following a small fire; timber frame buildings are built to superficially resemble buildings of ordinary construction.

Table 2: Fires in timber frame dwellings, England (2009-2010)

Area of fire and heat damage	No special construction		Light timber frame		Total
None	11,146	99%	79	1%	11,225
0-5m^2	18,561	99%	164	1%	18,725
6-10m^2	2,179	98%	41	2%	2,220
11-20m^2	1,377	98%	26	2%	1,403
21-50m^2	767	97%	26	3%	793
51-100m^2	238	94%	14	6%	252
101-200m^2	75	94%	5	6%	80
201-500m^2	25	93%	2	7%	27
501-1,000m^2	10	91%	1	9%	11
Over 1,000m^2	6	86%	1	14%	7
Total (21m^2 or greater)	1,121	96%	49	4%[(a)]	1,170
Total (all sizes)	34,384	99%	359	1%	34,743
(a) In 2009-2010: Timber frame buildings accounted for 4% of all dwelling fires, where the type of construction is assumed to be identified.					

Table 3: Fires in timber frame dwellings under construction, England (2009-2010)

Area of fire heat and damage	No special construction		Light timber frame		Total
None	39	97%	1	3%	40
0-5m^2	97	89%	12	11%	109
6-10m^2	34	89%	4	11%	38
11-20m^2	16	94%	1	6%	17
21-50m^2	19	90%	2	10%	21
51-100m^2	13	81%	3	9%	16
101-200m^2	8	67%	4	33%	12
201-500m^2	1	33%	2	67%	3
Over 500m^2	0	0%	3	100%	3
Total (all Sizes)	227	88%	32	12%[(a)]	259
(a) 2009-2010: Timber frame dwellings accounted for 12% of all fires for dwellings under construction.					

Fires of over $20m^2$ are very likely to have extended beyond the boundary of one room, especially in residential dwellings. This therefore provides a valid starting point for assuming a buildings construction method has been correctly identified. This assumption is also outlined in the CLG report.

For buildings under construction, there is unlikely to be a problem identifying whether timber frame or ordinary construction methods have been used, thus all the fires are included in the analysis.

5.1.1 Fires in timber frame dwellings in England

Using the CLG data to analyse fires in timber frame dwellings in England, we derive the results in Table 2.

If the estimate of 1.7% for timber frame market share of residential buildings in England is used as a benchmark, then the CLG data suggests that in 2009 it was more than twice as likely for a fire to occur in a LTF building than that of ordinary construction.

This is a surprising result, as the building construction material should have no effect on the probability of a fire occurring. Speculation can only suggest that potential ignition events taking place in buildings of ordinary construction are less likely to result in the event of being officially recorded as a fire.

Whilst number of fire ignitions may be a constant factor, it is possible that the construction techniques involved contribute to the development of the event to the point where the emergency services become involved, thus the fire is officially recorded.

As recognised by the CLG report (which utilised the Pearson's Chi-Squared test for statistical analysis), the data shows that fires in timber frame dwellings appear to incur greater areas of damage than conventional build methods.

It should be noted that this data only represents statistics from 2009-10.

For analysis of fires in timber frame non-residential buildings in England, see Appendix 10.1.1. Although this data is of interest, it is not analysed in depth as there is currently no estimate for LTF market share for non-residential buildings in England, and therefore no conclusions can be drawn.

5.1.2 Fires in timber frame dwellings under construction in England

Using the CLG data to analyse timber frame dwellings under construction, we derive the results in Table 3.

In 2009, timber frame buildings accounted for 17% of all new residential buildings in England (Table 1), which is less than the 12% of fires seen in timber frame residential buildings under construction.

However, when 44% of fires in a timber frame dwellings under construction resulted in damage of over $21m^2$ compared to 18% of fires in dwellings of no special construction, the table suggests that these fires are likely to result is considerably greater area damage.

CLG concluded: 'Fires in timber frame dwellings do tend to have a greater area of fire and heat damage than in dwellings of no special construction.'

For analysis of fires in timber frame non-residential buildings under construction in England, see Appendix 10.1.2.

6. FIRE STATISTICS FOR THE UNITED STATES

6.1 Large loss fires

The following data has been collated from reports published by the National Fire Protection Association 2003-2008, reporting on large loss fires in the United States.[23] The intent of these reports is to highlight large financial losses caused by fires in the United States.

The threshold defining a large loss fire was $5 million, rising to £10 million post-2007. This was changed to fall in line with increases in the Consumer Price Index, since the $5 million threshold was set in 1987. No adjustment was made for inflation for all year on year comparisons.

To ensure the most robust data set has been evaluated for large loss fires, all the information between 2003 and 2008 has been collated together.

Note: In the context of large loss fires, residential buildings do not include university accommodation (as previously defined) since this data set has been further divided to include educational buildings.

Data in Table 4 (see page 10) is representative of large loss fires in the United States and so to ensure that singular large losses do not dominate the analysis, frequency and financial loss have been displayed in each sub category simultaneously.

Certain high risk categories predictably feature highly in both frequency and loss, most notably manufacturing properties.

Other prominent figures in the table include the most frequent sub-categories; unprotected wood frame buildings under construction and wood frame residential buildings. Although these types of buildings are likely to represent a large portion of overall market share, these large loss fires occurred despite the building height (and area) restrictions of three storeys and 40 feet in the United States for wood frame buildings.

6.1.1 Large loss fires 2003-2008: firefighter injuries

Table 5 (see page 10) outlines firefighter injuries sustained during large loss fires between 2003 and 2008.

From the descriptions accompanying each large loss fire, examples of which can be found in the Appendices, it is unclear how these specific firefighter injuries were sustained.

However, analysis in the NFPA journal does shed light on firefighter deaths in structure fires:[24]

'Two-hundred-and-fifty firefighters died of injuries suffered at structure fires from 1997 to 2006. Of those, 44 were killed inside buildings as a result of structural collapses… full details on construction are not available for many of the collapse incidents, but trusses were involved in the collapse in seven incidents. These seven incidents claimed 12 lives. Five firefighters died in two roof collapses where wood trusses, described as pre-engineered wood and lightweight wood, were involved. Three firefighters were killed in two collapses involving lightweight wood floor trusses. Another was killed in a floor collapse involving open manufactured wood I-beams.'

For a breakdown of civilian injuries and fatalities, see Appendix 10.1.3.

23. Stephen G Badger, (2003-2008) Large-Loss Fires in the United States [Online] Available: http://www.nfpa.org/ [13/10/2010].

24. NFPA Journal (2009) Light Weight, Heavy Concern: July/August 2009, pg. 41 [Online] Available www.nfpajournal.org [11/11/2010].

Table 4: Large loss fires, United States (2003-2008)

(0) refers to the number of large loss fires recorded and $(000,000s) refers to the financial loss sustained for each sub-category.	Basic industry	Educational	Manufacturing	Public assembly	Residential	Special properties	Storage	Store and office	Under construction	Totals
Protected non-combustible	(0)	(1)	(5)	(4)	(2)	(1)	(2)	(6)	(1)	(22)
	$0	$34	$30	$31	$108	$5	$10	$53	$12	$283
Unprotected non-combustible	(3)	(0)	(19)	(0)	(0)	(1)	(8)	(1)	(0)	(32)
	$88	$0	1073	$0	$0	$6	$84	$5	$0	$1,256
Protected ordinary	(0)	(1)	(1)	(0)	(1)	(1)	(0)	(0)	(0)	(4)
	$0	$9	$50	$0	$5	$5	$0	$0	$0	$69
Unprotected ordinary	(1)	(6)	(9)	(6)	(11)	(4)	(6)	(9)	(3)	(55)
	$16	$58	$96	$52	$108	$92	$90	$110	$43	$664
Heavy timber	(0)	(1)	(8)	(0)	(0)	(4)	(3)	(2)	(2)	(20)
	$0	$14	$95	$0	$0	$31	$19	$43	$46	$247
Protected wood frame	(0)	(0)	(1)	(0)	(4)	(0)	(1)	(0)	(0)	(6)
	$0	$0	$15	$0	$41	$0	$5	$0	$0	$61
Unprotected wood frame	(0)	(2)	(3)	(4)	(14)	(1)	(0)	(1)	(29)	(54)
	$0	$48[a]	$49	$61	$101[c]	$9	$0	$5	$346[d]	$622
Not reported	(9)	(2)	(13)	(3)	(5)	(2)	(9)	(2)	(7)	(52)
	$126	$12	$432	$26	$60	$15	$177	$12	$139	$997
	(13)	(13)	(59)	(17)	(37)	(14)	(29)	(21)	(42)	(245)
	$230	$174	$1,839[b]	$169	$423	$162	$385	$229	$589	$4,200

(a) In this time, two large loss fires have occurred in educational buildings of timber frame construction, with an average loss of $24million.
(b) Manufacturing fires account for the most prevalent and costly events in completed buildings, due to the substantial scope for expensive property losses, machinery losses and personnel injury.
(c) Unprotected wood frame residential buildings are the third most frequent large loss fires in the United States. This is evident despite the height and area limitations imposed on LTF buildings.
(d) Unprotected wood frame buildings under construction are the most frequent large loss fires.

Table 5: Firefighter injuries sustained during large loss fires in the United States (2003-2008)

(0) refers to the number of large loss fires recorded in each category and 0 refers to the number of injuries.	Basic industry	Educational	Manufacturing	Public assembly	Residential	Special properties	Storage	Store and office	Under construction	Totals
Protected non-combustible	(0)	(1)	(5)	(4)	(2)	(1)	(2)	(6)	(1)	(22)
	0	0	1	0	2	0	2	5	0	10
Unprotected non-combustible	(3)	(0)	(19)	(0)	(0)	(1)	(8)	(1)	(0)	(32)
	1	0	5	0	0	0	0	0	0	6
Protected ordinary	(0)	(1)	(1)	(0)	(1)	(1)	(0)	(0)	(0)	(4)
	0	0	0	0	1	0	0	0	0	1
Unprotected ordinary	(1)	(6)	(9)	(6)	(11)	(4)	(6)	(9)	(3)	(55)
	0	5	5	2	1	6	3	19	2	43
Heavy timber	(0)	(1)	(8)	(0)	(0)	(4)	(3)	(2)	(2)	(20)
	0	0	9	0	0	2	2	0	2	15
Protected wood frame	(0)	(0)	(1)	(0)	(4)	(0)	(1)	(0)	(0)	(6)
	0	0	0	0	2	0	0	0	0	2
Unprotected wood frame	(0)	(2)	(3)	(4)	(14)	(1)	(0)	(1)	(29)	(54)
	0	0	5	4	26[b]	8	0	0	11	54[a]
Not reported	(9)	(2)	(13)	(3)	(5)	(2)	(9)	(2)	(7)	(52)
	3	2	0	0	12	1	3	0	13	34
	(13)	(13)	(59)	(17)	(37)	(14)	(29)	(21)	(42)	(245)
	4	7	25	6	44	17	10	24	28	165

(a) Of all types of building construction, unprotected wood frame buildings account for the most firefighter injuries in large loss fires.
(b) Of unprotected wood frame construction, residential buildings caused the most firefighter injuries.

6.2 Catastrophic multiple death fires in the USA

The following data has been collated from documents published by the National Fire Protection Association between 2004 and 2009, which report on catastrophic multiple death fires in the United States.[25]

The threshold defining a catastrophic multiple death fire is set by the NFPA and differs for residential and non-residential properties:

- in residential properties, five deaths or more qualifies as a catastrophic multiple death fire; and
- in non-residential properties, three deaths or more qualifies as a catastrophic multiple death fire.

Fires that fall outside these definitions do not feature in the NFPA report. Fires in unprotected wood frame buildings accounted for 320 fatalities out of a total of 524 residential fatalities, making up a total of 61% of the fatalities.

Comparing this with the benchmark of 90% LTF residential market share in the United States, 61% could be considered lower than expected, even when taking into consideration only the unprotected buildings.

However, the context of this data should again be considered. Multiple fire deaths should be an exceedingly rare event at the best of times, especially in the context of the building height and area limitations imposed that should significantly reduce the number of catastrophic multiple death fires seen.

Table 6: Catastrophic multiple death fires in the United States (2004-2009)

	Number of...	Residential	Non-Residential	Totals
Protected non-combustible	Fires	1	2	**3**
	Fatalities	9	15	**24**
Unprotected non-combustible	Fires	1	2	**3**
	Fatalities	6	19	**25**
Protected ordinary	Fires	3	0	**3**
	Fatalities	19	0	**19**
Unprotected ordinary	Fires	15	4	**19**
	Fatalities	96	17	**113**
Heavy timber	Fires	0	0	**0**
	Fatalities	0	0	**0**
Protected wood frame	Fires	2	1	**3**
	Fatalities	17	5	**22**
Unprotected wood frame	Fires	54	10	**64**
	Fatalities	320	18	**338**[(a)]
Not reported	Fires	11	14	**25**
	Fatalities	57	65	**122**
Totals	Fires	**87**	**33**	**120**
	Fatalities	**524**	**139**	**663**

(a) Over half the fires and over half the fatalities took place in unprotected wood frame buildings.

25. Stephen G Badger, (2004-2009) Catastrophic Multiple-Death Fires [Online] Available: http://www.nfpa.org/ [13/10/2010].

7. FIRE FATALITIES IN THE UK AND THE UNITED STATES

7.1 Total fire fatalities in the UK and the USA

It is possible to provide a direct comparison between fire deaths in the UK and the United States using data collected by the Geneva Association (the International Association for the Study of Insurance Economics).[26]

On average between 2003 and 2007, for every 100,000 populace, there were:

- 0.88 fire-related deaths in the UK; and
- 1.32 fire-related deaths in the United States.

Note: This data includes fire related deaths for both civilians and firefighters.

7.2 Fatalities in domestic fires

A useful indicator for assessing LTF building fire fatalities is the number of fire-related deaths occurring in the home. The results can then be compared for the USA and the UK, which have high and low percentage timber frame market shares respectively.

Using data from the NFPA (2005-2009) and the CLG Fire Statistics Monitor (2004-2007), it can be calculated that on average:

- 72% of fire-related deaths occur in the home in the UK;[27] and
- 83% of fire-related deaths occur in the home in the USA.[28]

Using this information, and the data from 7.1, it is possible to compare the number of fatalities in the home, per capita.

It is estimated that on average, for every 100,000 populace, there are:

- 0.63 fire related deaths in the home, in the UK; and
- 1.10 fire related deaths in the home, in the USA.

This estimate shows that there is nearly twice the amount of fire related deaths occurring in homes in the United States than in the UK, per capita.

7.3 Cost of active and passive fire protection in dwellings

In the United States, 2.5% of the total national cost of building and construction is spent on fire protection for homes. This is in comparison to 1% spent in the UK.[26]

This casts further doubt over the fire performance of LTF buildings, as nearly twice the amount of fire related deaths per capita occur in homes in the United States compared to the UK, despite considerably more investment in building fire protection as shown.

26. The Geneva Association, (2003-2010) World Fire Statistics [Online] Available: http://www.genevaassociation.org/affiliated_organizations/wfsc.aspx [02/11/2010].

27. Communities and Local Government, (2004-2007) Fire Statistics Monitor [Online] Available: http://www.communities.gov.uk/documents/ [02/11/2010].

28. Michael J Karter, Jr, (2005-2009) Fire Loss in the United States [Online] Available: http://www.nfpa.org/ [13/10/2010].

8. RESIDENTIAL FIRES IN THE UK AND THE UNITED STATES

8.1 Property fire loss in the USA

The following data has been collated from documents published by the National Fire Protection Association between 2004 and 2009, which report on total fire loss in the United States.[29] The total fire loss estimates are based on data reported to the NFPA by fire departments that responded to the National Fire Experience Survey.

Financial losses shown include overall direct property loss to contents, structures, vehicles, machinery, vegetation, and anything else involved in a fire. It does not include indirect losses, eg business interruption or temporary shelter costs. No adjustment was made for inflation in the year on year comparisons.

All the information has been collated between 2004 and 2009 to ensure the broadest and therefore most consistent data set possible.

8.1.1 Breakdown of fire loss in residential buildings in the USA

Note: 'Other residential' includes hotels, motels and university accommodation.

Using this data to recalculate the fire losses related to dwellings in the United States: dwelling fires now account for 76% of all building fires in the United States and 71% of all financial loss sustained from building fires in the United States.

29. Michael J Karter, Jr, (2004-2009) Fire Loss in the United States [Online] Available: http://www.nfpa.org/ [13/10/2010].

30. Office of the Deputy Prime Minister, (1999-2004) The Economic Cost of Fire [Online] Available: http://www.communities.gov.uk/fire/researchandstatistics/firestatistics/economiccost/ [14/10/2010]

If the benchmark of 90% timber frame market share of dwellings is applied to this data then fires in LTF buildings could account for nearly two-thirds of all financial loss related to all buildings fires.

8.2 Property fire loss in England and Wales

To provide a comparison with the loss figures reported for the United States, Table 9 represents figures for England and Wales. This data was extracted from reports compiled by the Office of the Deputy Prime Minister, investigating the economic losses associated with fire.[30]

As before, financial losses shown only include direct property loss resulting from fire and no adjustment was made for inflation in the year on year comparisons.

This data provides an interesting comparison with property fire loss in the United States.

Fires in dwellings in the United States accounted for 76% of all buildings fires, which is comparable to 71% in England and Wales However, in the United States, these dwelling fires accounted for 71% of all financial loss incurred, when compared to only 35% in England and Wales.

Despite the many differences between the data sets that might account for this large disparity, the obvious difference is the variation in the use of timber frame construction and the increased damage and cost that follow.

All this might imply that fires in LTF buildings result in more fires, which incur greater damage and financial loss, than buildings of no special construction.

Table 7: Property fire loss estimates in the United States (2004-2009)

(0) refers to the number of fires recorded and $(000,000s) refers to the financial loss sustained for each sub-category.	Basic industry	Educational	Institutional	Public assembly	Residential	Special properties	Storage	Store and office
2009	(9,500)	(5,500)	(5,500)	(14,500)	(377,000)	(22,500)	(29,500)	(16,500)
	572	83	32	757	7796	98	791	713
2008	(10,000)	(6,000)	(6,500)	(14,000)	(403,000)	(25,000)	(30,000)	(20,500)
	1,401	66	22	518	8,550	459	661	684
2007	(11,500)	(6,500)	(7,000)	(14,500)	(414,000)	(24,500)	(31,000)	(21,500)
	779	100	41	498	7,546	362	670	642
2006	(11,500)	(6,500)	(7,500)	(13,500)	(412,500)	(23,000)	(29,500)	(20,000)
	573	105	42	444	6,990	141	650	691
2005	(11,500)	(6,000)	(7,500)	(13,500)	(396,000)	(23,500)	(30,000)	(23,000)
	376	67	40	320	6,875	238	590	287
2004	(12,000)	(7,000)	(6,500)	(13,000)	(410,000)	(21,500)	(32,000)	(23,500)
	423	68	25	316	5,948	200	748	586
Average	(11,000)	(6,250)	(6,750)	(13,833)	(402,167)	(23,333)	(30,333)	(20,833)
	687	82	34	476	7,284	250	685	667
Percentage (%)	(2)	(1)	(1)	(3)	(79)	(5)	(6)	(4)
	7	1	0	5	72[(a)]	2	7	7

(a) Residential fires account for 79% of all building fires in the United States and 72% of all financial loss sustained from building fires in the United States.

Table 8: Property fire loss estimates in the United States (2004-2009)

(0) refers to the number of fires recorded and $(000,000s) refers to the financial loss sustained for each sub-category.	One- and two-storey family homes	Apartments	Other residential	Residential (total)
2009	(272,500)	(90,000)	(14,500)	(377,500)
	6,391	1,225	180	7,796
2008	(291,000)	(95,500)	(16,500)	(403,000)
	6,892	1,351	307	8,550
2007	(300,500)	(98,500)	(15,000)	(414,000)
	6,225	1,164	157	7,546
2006	(304,500)	(91,500)	(16,500)	(412,500)
	5,936	896	158	6,990
2005	(287,000)	(94,000)	(15,000)	(396,000)
	5,781	948	146	6,875
2004	(301,500)	(94,000)	(15,000)	(410,500)
	4,948	885	115	5,948
Average	(292,833)	(93,917)	(15,417)	(402,167)
	6,029	1,078	177	7,284
Percentage (%)	73	23	4	100
	83[a]	15	2[b]	100

(a) 73% of residential fires occurred in 1 & 2 story family homes, which accounted for 83% of financial loss associated with residential building fires.
(b) Other residential only accounts for 4% of the fires and 2% of the financial loss associated with residential building fires.

Table 9: Property fire loss in England and Wales (1999-2000 and 2003-2004)

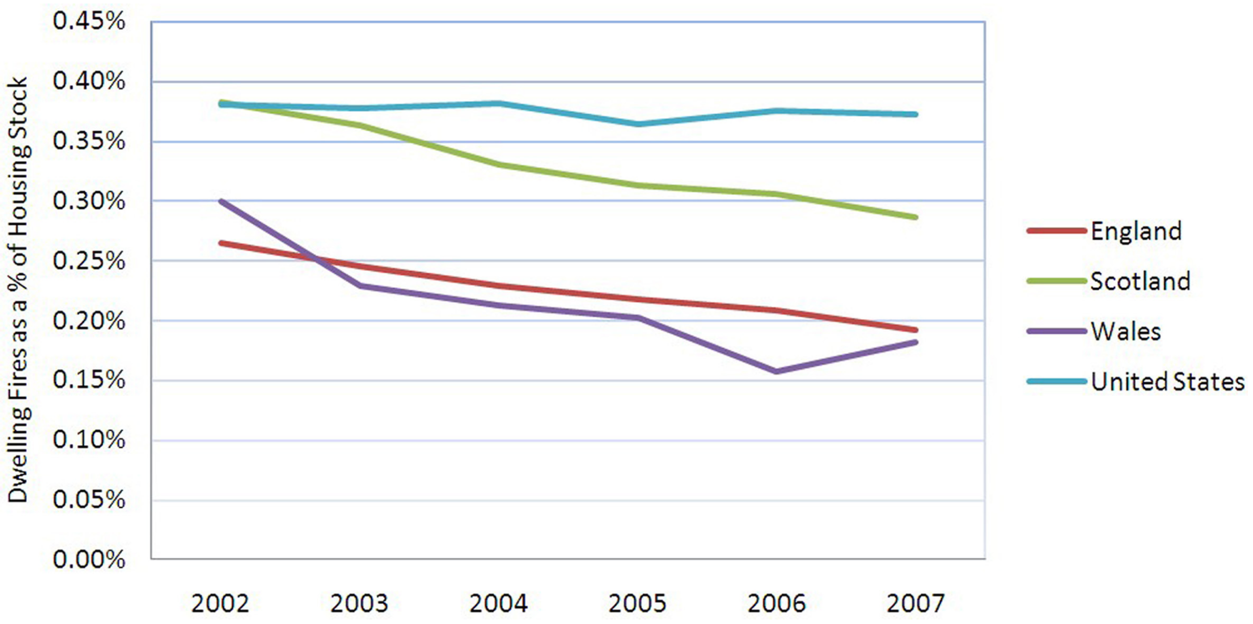
(0) refers to the number of fires recorded and $(000,000s) refers to the financial loss sustained for each sub-category.	Dwellings	Commercial	Public sector	Total
2004	(57,650)	(13,840)	(9,320)	(80,810)
	421	383	258	1,062
2003	(62,680)	(14,980)	(9,390)	(87,230)
	440	670	420	1,530
2000	(66,000)	(16,000)	(10,000)	(92,000)
	470	370	230	1,070
1999	(68,000)	(20,000)	(11,000)	(99,000)
	360	580	300	1,240
Average	(63,630)	(16,205)	(9,930)	(89,765)
	423	501	302	1,226
Percentage (%)	71	18	11	100
	35[a]	41	24	100

(a) Residential buildings account for 71% of all building fires and 35% of all financial loss associated with building fires.

Table 10: Dwelling fires in England, Scotland, Wales and the United States (2002-2007)

		England	Scotland	Wales	United States
2002	**Housing stock (HS)**	20,720,000	2,211,000	1,223,000	105,456,000
	Dwelling fires (DF)	54,840	8,448	3,660	401,000
	DF as a % of HS	0.265	0.382	0.299	0.380
2003	**Housing stock (HS)**	20,902,000	2,230,000	1,236,000	106,566,000
	Dwelling fires (DF)	51,272	8,100	2,829	402,000
	DF as a % of HS	0.245	0.363	0.229	0.377
2004	**Housing stock (HS)**	21,062,000	2,249,000	1,247,000	107,673,000
	Dwelling fires (DF)	48,288	7,426	2,652	410,500
	DF as a % of HS	0.229	0.330	0.213	0.381
2005	**Housing stock (HS)**	21,299,000	2,271,000	1,260,000	108,819,000
	Dwelling fires (DF)	46,299	7,097	2,548	396,000
	DF as a % of HS	0.217	0.313	0.202	0.364
2006	**Housing stock (HS)**	21,515,000	2,291,000	1,272,000	109,982,000
	Dwelling fires (DF)	44,744	7,003	2,001	412,500
	DF as a % of HS	0.208	0.306	0.157	0.375
2007	**Housing stock (HS)**	22,190,000	2,314,000	1,285,000	111,162,000
	Dwelling fires (DF)	42,624	6,624	2,340	414,000
	DF as a % of HS	0.192	0.286	0.182	0.372
Average	**Housing stock (HS)**	21,281,000	2,261,000	1,254,000	108,276
	Dwelling fires (DF)	48,011	7,450	2,672	406,000
	DF as a % of HS	0.226	0.330	0.214	0.375

Figure 1: Dwelling fires in England, Scotland, Wales and the United States (2002-2007)



8.3 Residential fires in England, Scotland, Wales and the USA

As a comparison of residential fires in England, Scotland, Wales and the United States, it is possible to analyse the trends for the number of dwelling fires,[31,32] as a percentage of housing stock,[33,34] for England, Scotland, Wales and the United States.

Analysis of this data shows that on average between 2002 and 2007, dwelling fires were most prevalent in the United States, followed by Scotland and then England and Wales.

This trend is better represented in graphic form. Figure 1 illustrates the trends related to the number of dwelling fires as a percentage of housing stock, as calculated in Table 10.

An interesting comparison for this data shows that the increase in probability of a fire occurring could be a function of the LTF building market share for each region.

This surprising result supports the analysis of the CLG Fire Statistics Monitor, with LTF building fires appearing to be twice as common as a fire in a building of no special construction.

It is clear in this example that many factors will contribute to the variation in the probability of a fire occurring, particularly when comparing data from Great Britain and the United States. However, it would be expected that the number of variations experienced between England, Wales and Scotland should be negligible.

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9. CONCLUSION

The UK government has taken a bold move in the almost unrestricted allowance of LTF building methods within the UK. This report has demonstrated that even with quite restrictive controls in place, such as those used in the US, the continued expansion of LTF market share is likely to have significant implications for the insured environment which may extend to the safety of firefighting personnel and building occupants alike. Some of these changes are already manifest in the UK, with construction site losses mirroring the historic US experience and continued evidence of cavity fire issues and the greater material damage that arises.

Whilst the subject of this report has been focussed on LTF buildings, the findings may be equally relevant to all forms of MMC construction deploying combustible materials and to this end the reader is directed to the NHBC Foundation work on **Fire performance in highly insulated residential buildings** due to be published shortly in which similar issues could be inferred in some other novel build methods.

10. APPENDICES

10.1 Additional tables

10.1.1 Fires in timber frame non-residential buildings in England

Table 11 uses data from CLG's **Fire Statistics Monitor** to analyse fires in timber frame, non residential buildings in England.

10.1.2 Fires in timber frame non-residential buildings under construction in England

Table 12 uses data from CLG's **Fire Statistics Monitor** to analyse fires in timber frame, non residential buildings under construction in England.

Table 11: Fires in timber frame non-residential buildings, England (2009-2010)

Area of fire and heat damage	No special construction		Timber frame		Total
None	2,825	99%	28	1%	2853
0-5m²	5,481	98%	133	2%	5614
6-10m²	743	92%	64	8%	807
11-20m²	467	89%	58	11%	525
21-50m²	351	87%	54	13%	405
51-100m²	160	85%	29	15%	189
101-200m²	99	88%	14	12%	113
201-500m²	84	86%	14	14%	98
501-1,000m²	46	88%	6	12%	52
1,000-2,000m²	19	100%	0	0%	19
2,001-5,000m²	8	100%	0	0%	8
5,001-10,000m²	4	100%	0	0%	4
Over 100,000m²	3	75%	1	25%	4
Total (21m² or greater)	774	87%	118	13%[a]	892
Total (all sizes)	10,290	96%	401	4%	10,691
(a) Timber frame buildings accounted for 13% of all non-residential fires larger than 21m².					

Table 12: Fires in timber frame non-residential buildings under construction, England (2009-2010)

Area of fire and heat damage	No special construction		Timber frame		Total
None	24	96%	1	4%	25
0-5m²	72	96%	3	4%	75
6-10m²	25	96%	1	4%	26
11-20m²	14	88%	2	13%	16
21-50m²	14	74%	5	26%	19
51-100m²	8	100%	0	0%	8
101-200m²	2	50%	2	50%	4
201-500m²	2	50%	2	50%	4
Over 500m²	2	100%	0	0%	2
Total (all sizes)	163	91%	16	9%[a]	179
(a) Timber frame buildings accounted for 9% of all fires in non-residential buildings under construction.					

10.1.3 Large loss fires 2003-2008: civilian injuries and fatalities

In correspondence with Table 4, Table 13 outlines the civilian injuries and fatalities resulting from large loss fires in the United States between 2003 and 2008.

10.2 Large loss fires in wood frame buildings 2008

10.2.1 Maine

$30 million, July, 9.23am

This four-storey boat manufacturing facility was of unprotected, wood frame construction and covered 90,000ft² (8,360m²). The plant was operating at the time of the fire.

No information was reported on the facility's detection equipment. It had an unknown type of sprinkler system, but its coverage was not reported. The sprinklers activated initially, but then reportedly shut down. The reason it shut down was not reported.

Welding and cutting work on a tug boat was being done too close to a wall of the building, causing it to ignite. The fire was first spotted on the interior of the wall, then observed to be on the exterior of the roof and spreading.

Arriving firefighters found the structure fully involved. The fire spread to several other buildings in the boat yard and to three tugs under construction. It also damaged several nearby homes and several vehicles. One civilian was injured.

10.2.2 Connecticut

$13 million, April, 1.26am

This 120-unit, unprotected, wood frame apartment complex consisted of 20 three-storey buildings in two clusters of 10 that covered 33,750ft² (3,135m²). The complex was occupied by approximately 150 residents.

The complex had a complete coverage smoke alarm system, with detectors in the living rooms and bedrooms of each unit. The system activated and alerted the occupants of the building. There were also manual pull stations in the exit access corridors. There was no automatic suppression equipment.

A discarded cigarette ignited combustibles in or around a bucket on the rear deck of a first-storey apartment. The fire spread to the decking and siding materials and spread upward and throughout the complex.

This fire broke out during an extended dry spell when the fire danger reports were classified as extreme. A large quantity of combustible foliage next to the structure allowed for further propagation of the fire throughout the complex. Firefighters from a dozen fire departments responded.

10.2.3 Michigan

$10.5 million, April, 10.01am

This three-storey, 42-unit apartment building for older adults was of unprotected wood frame construction. Its ground floor area was not reported. It was occupied at the time of the fire.

The building had a complete coverage system of smoke alarms, but the system did not operate. The reason for this was not reported. It also had a complete coverage wet-pipe sprinkler system, but the system did not operate as the fire started in a concealed space, and heat in the voids and concealed spaces caused the piping to rupture.

Radiant heat from a boiler located on the third storey ignited the flooring and wooden structural members between the second

Table 13: Civilian injuries and fatalities sustained during large loss fires in the United States (2003-2008)

(0) refers to the number of large loss fires recorded in each category; 0-0 is number of injuries – number of fatalities.	Basic industry	Educational	Manufacturing[(a)]	Public assembly	Residential	Special properties	Storage	Store and office	Under construction	Totals
Protected non-combustible	(0)	(1)	(5)	(4)	(2)	(1)	(2)	(6)	(1)	(22)
	0-0	0-0	8-1	1-0	17-0	15-1	0-0	3-3	1-0	45-5
Unprotected non-combustible	(3)	(0)	(19)	(0)	(0)	(1)	(8)	(1)	(0)	(32)
	9-1	0-0	53-7	0-0	0-0	0-0	0-0	0-0	0-0	62-8
Protected ordinary	(0)	(1)	(1)	(0)	(1)	(1)	(0)	(0)	(0)	(4)
	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0	0-0
Unprotected ordinary	(1)	(6)	(9)	(6)	(11)	(4)	(6)	(9)	(3)	(55)
	0-0	0-0	0-0	0-0	4-2	2-0	0-0	0-0	0-0	6-2
Heavy timber	(0)	(1)	(8)	(0)	(0)	(4)	(3)	(2)	(2)	(20)
	0-0	0-0	9-1	0-0	0-0	0-0	0-0	0-0	0-0	9-1
Protected wood frame	(0)	(0)	(1)	(0)	(4)	(0)	(1)	(0)	(0)	(6)
	0-0	0-0	0-0	0-0	6-0	0-0	0-0	0-0	0-0	6-0
Unprotected wood frame	(0)	(2)	(3)	(4)	(14)	(1)	(0)	(1)	(29)	(54)
	0-0	0-0	1-0	0-0	7-2	3-0	0-0	0-0	1-0	12-2
Not reported	(9)	(2)	(13)	(3)	(5)	(2)	(9)	(2)	(7)	(52)
	0-0	0-0	54-6	0-0	0-0	0-0	0-0	0-0	0-0	54-6
Totals	(13)	(13)	(59)	(17)	(37)	(14)	(29)	(21)	(42)	(245)
	9-1	0-0	125-15	1-0	34-4	20-1	0-0	3-3	2-0	194-24

(a) Manufacturing fires account for the most injuries and fatalities, often as a result of inherent dangers associated with heavy industry manufacturing processes.

and third storeys. The fire travelled in hidden combustible voids in floor and wall spaces.

Firefighters made numerous rescues over ladders. Two civilians and one firefighter were injured. Losses were estimated at $7.5 million to the structure and $3 million to the contents.

10.2.4 New York

$10 million, November, 12.26pm

This one- and two-storey, 114-unit motel of unprotected wood frame construction was open and operating at the time of the fire. The ground floor area was not reported.

The motel had a complete-coverage smoke detection system that operated and alerted occupants and the fire department. It also had a complete-coverage wet-pipe sprinkler system. The system was not in the area of origin and was overwhelmed when fire spread into the area it covered.

The only information reported on fire development was that it began with an electrical malfunction in an attic.

The fire started in a void above a wooden tongue-and-groove ceiling and spread to an attic above the pool, then burned unchecked above the fitness area into guest rooms on the second storey and into the motel lobby. The ceiling and roof collapsed during the fire.

10.2.5 Minnesota

$24 million, April, 1,21am

This one- and two-storey apartment complex for older adults was of unprotected wood frame construction and covered 130,000ft^2 (12,077m^2). At the time, it was under construction but near completion. No one was at the site at the time. Neither detection nor suppression equipment had been installed.

The cause of this fire was listed as undetermined, but it started in the area of a workshop. A passing police officer spotted the fire and reported it.

10.2.6 Virginia

$10.27 million, September, 10.40pm

This four-storey hotel of unprotected wood frame construction was under construction. Its ground floor area and operating status were not reported. No information was reported on its fire protection systems.

Upon arrival, firefighters found the four-storey structure fully involved in fire. Embers had started several smaller fires in adjacent properties.

A defensive attack was begun, and the bulk of the fire was knocked down in 30 minutes. One firefighter was injured. The cause of the fire is under investigation.

10.2.7 California

$38 million, June, 4.50am

This was a large film studio and back lot for movies and television shows. The structures were of various heights and construction, with the majority of unprotected wood frame construction. The area covered was not reported. No information was reported on fire protection systems or fire development.

More than 400 firefighters responded to this fire. They were faced with several challenges, including a lack of water pressure and water supply, as well as explosions involving compressed gas containers, propane tanks, tires, and gas tanks of private vehicles. Firefighters were forced to draft water from lakes on the property.

10.2.8 Idaho

$10.5 million, December, 3.35pm

This one-storey country club of unprotected wood frame construction covered 30,000ft^2 (2,787m^2). The clubhouse was operating at the time.

The type of detection equipment could not be determined. The clubhouse had no suppression equipment.

The cause and origin of the fire were listed as undetermined.

10.3 Large loss fires in wood frame buildings 2007

10.3.1 Nevada

$19m; May, 6.11pm

This three-storey, 147-unit condominium building of unprotected wood frame construction was under construction. The building covered 209,800ft^2 (19,500m^2).

There was a security guard at the scene when the fire broke out. There was no automatic detection or suppression equipment present.

This was an incendiary fire, with no additional information reported. One firefighter was injured.

10.3.2 Wisconsin

$15m; March, 3.58am

This four-storey 73-unit senior living complex was under construction and nearly completed. It covered 151,600ft^2 (14,100m^2) and was of unprotected wood frame construction. There was no one in the building at the time of the fire. There were no automatic detection or suppression systems present.

This was an incendiary fire. No further information was reported. Two firefighters were injured. The loss was reported as $13m to the structure and $2m to contents.

10.3.3 Massachusetts

$14m; September, 12.04am

This three-storey retirement living complex covered 116,000ft^2 (10,800m^2) and was of unprotected wood frame construction. It was under construction and there was no one in the building at the time of the fire. There were no automatic detection or suppression systems present.

This incendiary fire was set in several locations. One firefighter was injured.

10.3.4 California

$12m; January, 1:57pm

This four-storey, 39-unit apartment building was of unprotected wood frame construction and was under construction. The ground floor area was not reported. Workers were on the job site at the time.

There was no detection system present. A sprinkler system was being installed at the time, but was not yet operable. The type and coverage of the system were not reported.

Hot tar from a tar kettle on the roof ignited the roofing materials.

10.3.5 Massachusetts

$11m; April, 1.53am

This four-storey apartment building was of unprotected wood frame construction and was under construction. The building covered 130,000ft^2 (12,100m^2). There was no one on the scene when the fire broke out.

There was no automatic detection or suppression equipment present. The cause and origin were undetermined.

The complex had poor water pressure and volume available. Firefighters had trouble locating working hydrants and so were delayed in getting hose lines into operation. In addition to the building of origin, the fire destroyed a 99-unit building, two 24-unit buildings, several garages, and a dozen pieces of construction equipment, as well as tools and building materials.

10.3.6 California

$10m; June, 12.56am

This two-storey, single-family house of unprotected wood frame construction was under construction. No information was reported on the ground floor area. No one was at the site at the time. No information was reported on detection or suppression systems.

The fire's cause was undetermined. Fire burned throughout the attic area and second-storey floor joists.

10.3.7 California

$8.5m; June, 1.49am

This four-storey, 80-unit hotel of unprotected wood frame construction was under construction, in the framing stages. The ground floor area and operating status were not reported.

A detection system and automatic suppression system were being installed at the time. The types and coverage of the systems were not reported, but neither was yet operable.

A fire of unknown cause broke out on the second storey. Fire spread was very rapid because of the framing material. The building was fully engulfed when firefighters arrived. Radiant heat caused heavy damage to surrounding buildings, vehicles and vegetation. Arriving firefighters were unable to mount an interior attack due to the large volume of fire. Master stream devices were set up to attack the fire.

Loss was listed as $2.5m to the original building and $6m to the exposures.

10.3.8 Texas

$8.5m; September, 6.56am

This three-storey, 49-unit motel was of unprotected wood frame construction and was under construction. (It was due to open in a very short time.) The structure covered 60,000ft^2 (5,600m^2). It was not reported if anyone was at the site at the time.

There was no information on any detection system. There was a dry-pipe sprinkler present. Its operation and coverage were not reported.

Loss to the building was listed at $8m and $500,000 to the contents.

10.3.9 California

$6,617,988; January, 1.49pm

This four-storey apartment building of unprotected wood frame construction was under construction. No other details were reported.

10.3.10 Maine

$10m; August, 4.53am

This occupied, four-storey, 10-unit apartment building was of unprotected wood frame construction and covered 7,200ft^2 (670m^2).

There was a full coverage smoke detection system present. The system operated. There was a full coverage wet-pipe sprinkler system present, but there was no coverage in the attic area. The system activated when fire spread down from the attic into living areas.

A propane grill on a third-storey balcony ignited wood construction members and fire spread to the soffit and undetected into and throughout the attic area.

Damage was estimated at $5m to the structure and $5m to the contents.

10.3.11 Colorado

$6m; January, 1.00am

This was an occupied three-storey apartment building of unprotected wood frame construction. This fire was deliberately set and two civilians died in this fire. No additional details were reported due to litigation.

10.3.12 Ohio

$5.5m; October, 5.01am

This was an occupied, three-storey, 32-unit apartment building that covered 41,190ft^2 (3,800m^2) and was of unprotected wood frame construction. There were smoke alarms present. No additional details were reported. There was no automatic suppression equipment. A fire of unknown cause broke out in a first-storey apartment. No other details were available.

Estimated loss to the structure was $3m and $2.5m to the contents.

10.3.13 Alaska

$13,299,100; June, 7.16pm

This was a two-storey high school that covered 47,000ft^2 (4,400m^2) and was of unprotected wood frame construction. The building was unoccupied at the time.

There were detectors present, but the coverage and operation were not reported. There was a wet-pipe sprinkler system present. Its coverage was not reported. The fire department reported the system operated but there was not enough agent available. No further explanation was given. A fire of undetermined cause broke out on the exterior roof surface. No other details were reported.

The loss was estimated at $13,230,000 to the structure and $69,100 to the contents.

10.3.14 Michigan

$7m; February, 9.20pm

This one-storey country club covered 13,345ft^2 (1,240m^2) and was of unprotected wood frame construction. The club was closed for the night. There was a smoke detection system present. Its coverage was not reported but it operated. There was a full coverage wet-pipe sprinkler system present. The system operated, but there was no information on its effectiveness.

Investigators believe the fire started in the attic, but the cause is listed as undetermined. On arrival, firefighters found heavy smoke showing. After several attempts at an interior attack, all firefighters were withdrawn to a defensive attack. At the time of the fire, the temperature was 7°F (-14°C) with a wind chill of -23°F (-31°C). Ice and snow on the ground created hazardous operating conditions for the firefighters. One firefighter was injured. The loss was estimated at $4m to the structure and $3m to the contents.

10.4 Large loss fires in wood frame buildings 2006

10.4.1 Illinois

$11m; August, 12.47pm

This one-storey pet food manufacturing plant covered 48,000ft^2 (4,459m^2) and was of unprotected wood frame construction. The plant was closed for the weekend when the fire broke out.

There was no detection or automatic suppression equipment present. A fire of unknown cause broke out in the warehouse section of this plant.

Four firefighters were injured fighting this fire. The loss was estimated at $9m to the structure and $2m to the contents.

10.4.2 South Carolina

$8,153,000; October, 7.15pm

This 12ft (3.6m) hardwood flooring manufacturing plant covered 65,394ft^2 (6,075m^2) and was of unprotected wood frame construction. The plant was operating at the time of the fire. There was no automatic detection or suppression equipment present.

This incendiary fire was set by someone who used a lighter to ignite sawdust in the stockroom area. The fire spread upward and across the structure due to excessive sawdust and debris. The fire also spread rapidly through the adjoining area because of the large amount of raw flooring materials and wood stain products.

Housekeeping was an issue as sawdust and debris were allowed to build up. One firefighter was injured fighting the fire.

10.4.3 Virginia

$5m; January, 10.45am

This two-storey single-family home covered 4,500ft^2 (418m^2), and was of unprotected wood frame construction. The house was occupied at the time of the fire.

There was complete coverage smoke detection equipment. The fire originated on the exterior of the house and spread into an area not covered by the system. It was not reported if detectors operated once the fire extended into the living area. There was no automatic suppression equipment present.

Fireplace ashes were placed into a plastic trash container inside a wooden storage bin located outside the garage. The fire extended up the exterior of the vestibule connecting the house and garage. It then entered a void space below the roof and spread the length of the house in the attic.

One firefighter was injured. The loss was estimated at $3m to the structure and $2m to the contents.

10.4.4 Minnesota

$5.5m; July, 4.53pm

This three-storey, six-unit apartment house was of unprotected wood frame construction and covered a floor area of 12,500ft^2 (1,161m^2). The building was occupied.

There was a complete coverage smoke detection system present. The system was not a factor because the fire originated outside and spread into the building. It was not reported if the system operated or not. There was no automatic suppression equipment present.

Carelessly discarded smoking materials ignited patio furniture on a second-storey balcony. The fire extended to the third-storey deck then into the attic area.

Firefighters made an interior attack on the fire in the attic but conditions deteriorated rapidly and crews withdrew to defensive operations. The loss was estimated at $4m to the structure and $1m to the contents.

10.4.5 Washington

$13m; March, 12.05am

This three-storey, 100-unit university dormitory was under construction. It was of unprotected wood frame construction, and covered 15,000ft^2 (1,393m^2). No one was at the site when the fire broke out.

It was not known if detection equipment was installed yet. There was no automatic suppression equipment.

An incendiary fire, no additional information was reported.

10.4.6 California

$5.5m; October, 3.45am

This four-storey hotel was under construction, and was of unprotected wood frame construction.

No information was reported on the ground floor area. No one was at the site when the fire broke out.

This was an incendiary fire. No further information can be released due to ongoing investigation.

10.4.7 Alaska

$35m; August, 6.00am

This one-storey elementary school covered 12,540ft^2 (1,165m^2) of unprotected wood frame construction. The school was occupied at the time. This occurred in a remote village.

There was a complete coverage of an unknown type of detection equipment present. The system operated. There was no automatic suppression equipment present.

This incendiary fire was set under the schoolhouse. Due to high winds, the fire soon became a conflagration, spreading to 57 exposures, including 20 residential properties, three educational properties, 30 storage properties (including metal shipping containers), a store, a boiler room, a steam bath, and one other type of property. Also lost were multiple snow removal machines and other vehicles.

There was a delay in detecting the fire because it originated under the structure. The day of the fire, there were extremely high winds. Firefighters responded from villages and towns miles away.

10.4.8 Arkansas

$9,850,000; August, 2.23pm

This was a one-storey middle, junior and high school of unprotected ordinary construction that covered 101,000ft^2 (9,383m^2). The school was in session when the fire broke out.

There was a complete coverage combination heat and smoke detection system present. The system operated and alerted the occupants. There was no automatic suppression equipment present.

Sparks or embers from a short in a light fixture ignited nearby combustibles. The fire burned into the attic and spread rapidly because of the wood frame construction and plywood decking.

Firefighters attacked the fire inside. When conditions worsened, firefighters evacuated the building and used elevated master streams.

The lack of detection and suppression equipment in the attic prevented early detection and intervention. To complicate matters for the firefighters, a severe thunderstorm passed through the area, forcing firefighters to shut down all master streams until it was safe to resume the battle.

The loss was estimated at $9,100,000 to the structure and $750,000 to the contents.

10.5 Large loss fires in wood frame buildings 2005

10.5.1 Wisconsin

$10m; February, 10.20pm

This fire originated in a three-storey, eight-unit condominium building that was under construction. It was of unprotected wood frame construction and covered 25,000ft^2 (2,322m^2). There were 34 buildings in the complex, and the fire ultimately involved nine buildings. Some were complete but unoccupied and some were still under construction. Two buildings were completed and occupied. No one was on the construction site when the fire broke out.

There was no detection equipment installed yet. There was a sprinkler system present, but its type and coverage was not reported. The system was not operational.

Before leaving for the day, workers placed a portable heating unit in an elevator shaft to melt ice. The heater overheated wood framing materials installed in the shaft. The fire spread, engulfing the structure and spreading to another building that was under construction and a completed but unoccupied building. The fire department was notified by a neighbour in one of the occupied buildings. Upon arrival, firefighters found one building had burned to the ground, one was fully engulfed and one had upper storeys burning.

The buildings in the complex were only 20 feet apart, allowing the fire to spread to two other buildings, and embers ignited spot fires on several other of the nine buildings in the area, as well as dumpsters and construction equipment.

10.5.2 Montana

$5m; March, 8.51pm

This two-storey assisted living complex was under construction. The building had unprotected wood frame construction, covered 44,416ft^2 (4,126m^2), and had four wings. At the time of the fire, one wing was completely constructed; two wings had been framed, insulated and sheet rocked; and one wing was framed with some insulation and sheet rock. The site was closed for the night.

There was no information reported on detection equipment. There was a partial installed sprinkler system present. The system was not operational.

The fire originated in a portable propane-forced air heater. The heater was in an area where sheet rock was being installed. There were several propane heaters throughout the structure.

10.5.3 California

$16m; July, 2.35am

This three-storey, six-unit apartment building was of protected wood frame construction and covered 3,500ft^2 (325m^2). The building was occupied.

There was a single-station smoke alarm present in the unit of origin. The system did operate. There was no suppression equipment present. A spark or flame from equipment (type not reported) in the kitchen ignited nearby combustibles.

Six civilians were injured. The loss was listed as $10m to the structure and $6m to the contents.

10.5.4 New Jersey

$7,100,000; September, 1.41pm

This four-storey, eight-unit condominium was of unprotected wood frame construction and covered 4,225ft^2 (392m^2). The building was occupied.

There was complete coverage smoke detection equipment. The alarms sounded, but with a delay due to the fire's area of origin. There was a complete coverage wet-pipe sprinkler system present. There was no coverage in the area of ignition (outside). Upon arrival, the fire department pumped into the sprinkler system, but there was no effect on the fire spread.

This exposure fire began in the engine compartment of a car parked in a garage under the condominium structure. The garages were separated by wood latticework that allowed the fire to spread through the eight garages that contained vehicles, boats, and propane grills. The fire spread up cedar sidings and through the truss floor assembly of the condominium units above. The fire spread to several other buildings in the condominium complex. At least 35 fire departments responded to fight the fire.

The day of the fire was very hot and humid, with a wind of 15-20mph (24-32kph). There had been no rain for three weeks, causing the siding to be very dry. One side of the structure was on a bay, forcing firefighters to hand lay fire hoses. The open-web truss construction of floors and roof allowed for rapid spread.

Twenty-four firefighters and three civilians were treated for heat exhaustion and other injuries. The loss was $6m to structures and $1,100,000 to contents.

10.5.5 California

$5m; April, 7.55am

This restaurant was in a two-storey strip mall of unprotected wood frame construction. The mall contained eight units and covered a floor area of 20,000ft^2 (1,858m^2). The restaurant was closed at the time of the fire.

There was no fire detection or suppression equipment present. The fire originated in a concealed space above the ceiling and below the second floor. Due to the destruction, no cause was determined.

Three firefighters were injured. The loss was $4.5m to the structure and $500,000 to the contents.

10.6 Large loss fires in wood frame buildings 2004

10.6.1 Texas

$11m; August, 5.56pm

This four-storey, 100-unit apartment building was of unprotected wood frame construction covering 32,000ft^2. The building was under construction at the time. Some workers were at the site when the fire broke out.

There was no detection equipment yet installed. There was a complete coverage wet-pipe sprinkler present but it was shut down before the fire due to a leak in the system.

A fire of unknown cause broke out on the second level of the building. Wind helped spread the fire throughout the units in the section of the building that was still in the framing phase. The fire spread to a parking garage then ignited a structure on the opposite side of the street.

Despite openings not yet protected by fire-rated doors, fire walls were effective in limiting the spread of fire. Two firefighters were injured.

10.6.2 Kansas

$8.5m; March, 2.22am

This four-storey senior citizen centre was of unprotected wood frame construction and covered 144,000ft^2. The building was under construction and no one was on the site at the time of the fire. There was no automatic smoke detection or suppression system present.

This incendiary fire was set on the first storey using available materials. Openings in the construction and doors left open contributed to the fire's spread. This was the second fire at this building in two days, and one of a series of arson fires in the area.

One firefighter was injured. Loss to the structure was estimated at $8m and $500,000 to the contents.

10.6.3 Maryland

$7m; December, 4.54am

Fires were set in over two dozen single-family dwellings of unprotected wood frame construction. The homes were under construction at the time. No one was at the site when the fire broke out. No information on detection equipment or suppression equipment was reported.

These incendiary fires were set in multiple areas and involved multiple materials. Fires were set in or spread to 41 homes, destroying at least 10 and severely damaging 16 of them. The homes were in various stages of construction. Multiple fires stretched firefighting resources thin, requiring mutual aid from several areas.

10.6.4 Virginia

$6m; March, 12.33pm

This five-storey apartment building was of unprotected wood frame construction. The ground floor area was not reported. The apartment building was under construction at the time of the fire. Construction workers were on the site at the time. There was no detection equipment or suppression equipment present.

This fire of unknown cause originated in a trash chute near the second storey. Fire spread rapidly up the chute and spread to the walls of the building. When the roof collapsed, polystyrene roof insulation fell into the fire and soon became flying burning embers that spread the fire to at least 25 other structures and 20 vehicles over a 20-block area.

Damage to structures and vehicles is estimated to be at least $6million, with the tally still ongoing. One civilian injury was reported.

10.6.5 Massachusetts

$5,800,000; May, 11.45am

This three-storey 48-unit apartment building was of unprotected wood frame construction and covered 9,000ft^2. The building was under construction at the time of the fire, and workers were at the site. There was no automatic detection equipment or suppression equipment present.

The only information reported was that the fire began in palletised materials and spread rapidly throughout the structure. Upon arrival, firefighters found the building totally involved in fire. Gusting winds helped spread the fire throughout the building. Two firefighters were injured.

10.6.6 Idaho

$5m; November, 4.41am

This two-storey apartment building was of unprotected wood frame construction and covered 8,736ft^2. The building was under construction and there was no one at the site when the fire broke out. There was no automatic smoke detection equipment or suppression system present.

Cardboard boxes of sheet rock mud were placed next to a portable propane heater on the first-storey. Once the boxes ignited, the fire compromised the fuel line to the heater. Fuel was released and ignited and the fire spread to an adjoining garage containing other building materials.

Upon arrival, firefighters found the building of origin fully involved with fire and direct fire impingement on a 1,000 gallon propane tank located outside in the rear of the structure. Firefighters provided protection for the threatened tank and exposures. One firefighter was injured. Loss to the structure was estimated at $4.5m and $500,000 to the contents.

10.6.7 Maryland

$7m; March, 5.00pm

This two-storey, single-family home was of protected wood frame construction and covered 14,000ft^2. The home was occupied at the time of the fire.

There was a complete coverage smoke detection system present in the house, all levels and sleeping areas were covered. There was no detection equipment in the garage, where the fire originated. It is not known if the system activated in the house. There was no suppression system present.

Juveniles playing with matches ignited newspapers in the garage. A cardboard box was used to smother and extinguish the fire. Not realising that the box was burning, the juveniles placed it in a trash pile in the garage and went into the house. Upon leaving the house about 20 minutes later, they found the garage well-involved with fire. Upon arrival, firefighters found that the fire had spread into the attic of the house.

No one met the firefighters upon their arrival, so crews began searching the house for possible occupants in need of rescue, which delayed their initial suppression activities. This house was in a rural area with no municipal water supply.

10.6.8 Maine

$6m; March, 12.25pm

This 3½-storey, seasonal, mansion-style home was of unprotected wood frame construction and covered 7,000ft^2. The house was built in the early 1900s and was situated on a rise overlooking the ocean.

There was a partial coverage system of smoke alarms present. The locations of the alarms were not reported. The system did activate and alerted workers who were present at the time. No suppression system was present.

Workers were removing paint with an electric heat gun. The heat ignited wood behind shingles at the second-storey level on the ocean side of the home. The fire burned up the inside of the wall to the attic and roof area.

Balloon construction allowed the fire to spread in the wall space. Forty-mile-per-hour winds off the ocean also enhanced the fire spread throughout the structure. Damage to the structure was listed as $5.5m and $500,000 to the contents.

10.6.9 Georgia

$6m; April, 7.27am

This three-storey town house apartment building (7 to 20 units) was of unprotected wood frame construction. The ground floor area was not reported. Several units were occupied at the time of the fire.

There was a smoke detection system present. The coverage was not reported but the system did activate. There was no suppression system present.

A grass fire ignited this structure. The cause of the grass fire has not been determined. The fire spread vertically up the structure. The fire reached and eventually spread throughout the attic area. The fire also spread laterally via the floor joist system to several units.

Then the fire department arrived, the structure was heavily involved in fire. Accessibility in the rear was a problem due to a hill. Two civilians were injured when they jumped from balconies. Loss to the structure was placed at $4m and to the contents at $2m.

10.6.10 Massachusetts

$5.5m; April, 8.22pm

This 2½-storey single-family home was of unprotected wood frame construction and covered 5,000ft^2. The home was occupied, with residents located on the first storey.

There was a partial coverage smoke detection system present. Alarms were located in the second-storey hallway. There were no alarms in the area of origin (the attic) but alarms did activate. There was no suppression system present.

Electrical equipment above a recessed light in a second-storey bedroom malfunctioned and ignited wood structural members. The fire spread undetected in the large open attic area for some time before detection. Arriving firefighters found heavy fire conditions throughout the attic.

Lack of detection equipment in the attic allowed the fire to burn undetected. The damage was listed as $3,100,000 to the home and $2,400,000 to contents.

11.6.11 Virginia

$5m; December, 3.50pm

This two-storey, single-family home was of unprotected wood frame construction. The ground floor area was not reported. The home was occupied at the time.

There was a complete coverage system of smoke detection equipment in the home, on all levels and sleeping areas. There were no alarms in the area of origin (the garage). The alarms activated in the home. There was no suppression system present.

As the homeowner worked on his car in an attached garage, the fuel tank, which he was removing, struck the vehicle's battery, creating a spark and fire. The fire spread throughout the entire garage as the owner attempted to extinguish the fire. The fire spread into and throughout the home.

Loss was estimated as $2m to the home and $3m to the contents.

11.6.12 Ohio

$15m; March, 7.54pm

This 50ft-high sawmill was of protected wood frame construction. The ground floor area and operating status were not reported.

There was no information reported on automatic detection equipment. There was no automatic suppression equipment.

This suspicious fire broke out in bulk storage of wood product.

11.6.13 Minnesota

$5m; January, 11.15pm

This 14ft-high fire station was of protected wood frame construction and covered 2,400ft^2. A second building of 3,800ft^2 belonging to the fire department was also damaged. Both buildings were unoccupied at the time.

There was no smoke detection or suppression equipment present.

A still undetermined source ignited an LP gas leak. The resulting explosion and fire destroyed the smaller of the two buildings and damaged the other. The fire department lost seven vehicles, all personal protection equipment as well as breathing apparatus and rescue equipment.

When firefighters arrived at the station they found their apparatus on fire and destroyed.

11.6.14 California

$5m; January, 2.00am

This one-storey office property was of unprotected wood frame construction. The area covered was not reported. The building was closed for the night. There was no automatic detection or suppression system present.

A fire broke out when two strip-type circuit breakers (relocateable power taps) in tandem overheated and ignited carpeting in an office. The fire spread to the room and contents, then to the attic and throughout the structure.

11.7 Large loss fires in wood frame buildings 2003

11.7.1 Nevada

$15m; September, 8.27pm

This two-storey apartment complex of unprotected wood frame construction covered 30,000ft^2 (2,787m^2) and was under construction. No one was on the site at the time of the fire. A detection system was present and activated, however the type and coverage weren't reported. No information was reported on any automatic suppression equipment.

Firefighters arriving at this incendiary fire found several multi-family dwellings fully engulfed in fire. The fire spread to, and destroyed or damaged, 23 structures. The fire spread rapidly due to the openness of the structures in the building phase.

11.7.2 California

$9m; May, 4.38am

This three-storey apartment was of unprotected wood frame construction. The ground floor area was not reported. No one was on the site at the time of the fire. No automatic detection or suppression systems were present and the structures were still under construction.

Firefighters responding to this incendiary fire found two three-storey apartment buildings fully involved in fire and spreading rapidly. This fire destroyed or damaged numerous structures still in the construction phase, as well as several vehicles.

Four firefighters were injured. Large amount of exposed wood spread the fire rapidly. Loss to the building was $8m and loss to contents was $1m.

11.7.3 Oregon

$8,020,000; March, 6.23am

This three-storey unprotected wood frame apartment building that was under construction covered 75,000ft^2 (6,967m^2). The operating status wasn't reported. No automatic detection or suppression systems were present.

Firefighters arriving at this incendiary fire found the structure heavily involved. The fire entered the attic area of a nearby occupied senior citizen housing and burned throughout.

One firefighter, two senior home occupants and a police officer who was assisting in evacuations, were injured. Open construction allowed the fire to spread rapidly. Loss to the building was $6.5m and loss to contents $1,520,000.

11.7.4 Minnesota

$8m; June, 3.48am

This three to five-storey, multi-family dwelling complex of unprotected wood frame construction was still under construction and covered an entire block. No one was on the site at the time of the fire. No automatic detection or suppression systems were present.

The fire's cause and origin are undetermined. Eight dwellings and several vehicles were destroyed or damaged. Two firefighters were injured. High winds contributed to the number of exposure fires.

11.7.5 Nevada

$6,900,000; January, 2.32am

This three-storey apartment complex was of unprotected wood frame construction, covered 50,000ft^2 (4,645m^2), and was still in the construction phase. No information was reported on the operation of the site.

Firefighters arrived to find this incendiary fire had spread to and engulfed the entire project. At least three dwellings were damaged or destroyed.

11.7.6 Virginia

$12,823,900; February, 4.45am

This four-storey senior citizen apartment house of protected wood frame construction contained 100 units and covered 23,536ft^2 (2,186m^2). Of the 100 units, 81 were occupied.

There was a complete coverage combination heat and smoke detection equipment. The system operated but it wasn't in the area of origin. An arriving police officer activated a manual pull station to sound the alarm. There was a complete coverage wet-pipe sprinkler system but one head operated. This system also was not in the area of origin (outside balcony).

The cause of this fire is undetermined and it originated on a third-storey balcony. The fire spread up the exterior and entered the attic through roof soffits. It then spread horizontally and down to the apartments on the fourth and third floors.

The balconies were of combustible materials, allowing for ignition. Two firefighters were injured. Loss to the building was $9,823,900 and loss to contents was $3m.

11.7.7 Texas

$5,220,000; March, 12.05am

This three-storey, single-family dwelling of protected wood frame construction covered 14,585ft² (1,354m²) and was occupied when the fire broke out.

A partial coverage smoke detection system present operated and a partial coverage sprinkler system was present. The type and operation weren't reported, but the system wasn't in the area of origin.

The cause is undetermined. Arriving firefighters found a fire in the ceiling between the first and second storey, which spread rapidly in voids throughout the house. Firefighters were forced to a defensive attack. Loss to the house was $3,250,000 and loss to contents was $1,970,000.

11.7.8 New York

$7m; March, 4.17am

This two-storey adult group residence of unprotected wood frame construction covered 31,000ft² (2,879m²) and was under construction. No one was on the site at the time of the fire.

Complete coverage automatic detection equipment of an unreported type was present, but not operational. A sprinkler system was installed but the type and coverage weren't reported. This system also was not yet operational.

This fire originated in the basement. A propane-fuelled portable heater used to dry recently installed tile was too close to the combustible walls.

Firefighters found the structure fully involved in fire when they arrived. One firefighter was injured.

11.7.9 Georgia

$6m; May, 2.52pm

This two-storey, single-family summer rental property of unprotected wood frame construction covered 1,081ft² (100m²). This dwelling was beachfront property and empty except for workers there at the time of the fire. No automatic detection or suppression systems were present.

The open flame from a roofer's torch contacted wood roofing members. The fire smouldered unnoticed and after the roofers left, the winds off the water fanned the fire to a flaming stage. From this point, the fire spread rapidly and eventually destroyed or damaged three properties.

Winds off the water increased the rate of fire spread. There was only a 9ft separation between structures and access to one side of the structures was limited to foot traffic due to location on the beach. Loss to the structures was $5,527,000 and loss to contents was $473,000.

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