House fires; are modern contents and construction making them more dangerous.

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Abstract

NSWFB Fire Investigation and Research Unit continually undertake case study analysis of significant house fires. This analysis and recent statistical analysis of fire services response data indicates that the effectiveness of containing a fire to the object or room of origin has deteriorated slightly over the last five years. This domestic research resonates with research from other countries showing a possible increase in speed and ferocity of domestic fires. Furthermore, this is supported by a survey of the perceptions of operational firefighters within the NSW Fire Brigades. If confirmed, this change in the built residential environment will present an ever increasing risk to the life safety of both building occupants and firefighters.

To test this hypothesis NSW Fire Brigades has entered into a collaborative project with CSIRO to research changes in the residential environment in Class 1a dwellings (houses), looking in particular at changes over the last three decades that may affect life safety outcomes for residents and firefighters exposed to residential fires.

This paper will outline the findings and outcomes of this research and discuss the benefits of applied research that leads to evidence for the design, implementation and evaluation of strategic fire prevention policy.

Key Words

Residential fires, increasing ferocity, applied research, research partnership CSIRO.

1. Background

The Fire Investigation and Research Unit (FIRU) was started in 1987 as the Fire Investigation Unit (FIU). In 1998 the unit was expanded to include two research officers and the name was changed to the Fire Investigation and Research Unit (FIRU). Shortly after this an accelerant detection canine was added and shortly after that in 2000, a Technical Project Writer.

The initial primary focus was to address the high level of undetermined rates by providing specialist fire investigation and fire investigation training. When research was added the focus was broadened to include research of human behaviour, building behaviour and fire behaviour. This was done to take a holistic case study approach to provide contextual and interrelationship information to explain the interaction between the victims of fire, their particular environment and the actual fire that had occurred. It was recognised that while statistical analysis can identify "at risk groups", a case study research methodology can substantiate this quantitative analysis and can assist in identifying "at risk behaviours" and "at risk environments".

As part of this case study methodology FIRU conducted research into significant house fires, in particular those that resulted in fatality. This analysis and recent statistical analysis of fire services response data indicates that the effectiveness of containing a fire to the object or room of origin has deteriorated over the last five years (NSWFB 2005). This domestic research resonates with research from other countries showing a possible increase in speed and ferocity of domestic fires (Bukowski 2004).

This led to the development of a hypothesis that modern furniture and increased fire loads within light weight construction, plus open plan homes may be leading to fires that have a higher and faster heat release rate then was previously the case. If this is accurate then this in turn may lead rapidly to untenable conditions for occupants, faster fire break out from the room of origin and to a quicker building collapse.

If this hypothesis can be shown to be accurate then there are some serious concerns for the way fire services undertake service delivery. Strategic planning for fire station locations based on the standard time temperature curve may no longer be relevant. Decreasing escape times for occupants coupled with increasing risk to firefighters from flashover would mean that we would need to adjust the way we fight fires, optimise our early intervention and prevention strategies and increase out efforts aimed at influencing and changing building codes for residential buildings.

2. Methodology, what we did to test the hypothesis

To test this hypothesis NSW Fire Brigades and CSIRO Fire Science and Technology Laboratory entered into a joint research project aimed at assessing changes in the Class 1a residential built environment that may have led to changes in levels of safety for occupants and firefighters. This project is made up of multiple stages and has been designed to improve our understanding of the interrelationship between building design; building construction and building contents and furniture.

Specifically the objective of the project is to identify changes in the domestic environment, in particular Class 1a buildings, over the last three decades that may affect life safety outcomes for residents and firefighters exposed to residential fires. In addition the project is to establish whether or not the current requirements of the BCA adequately reflect the risks associated with Class 1a buildings.
Stage one of the project has been completed and involved a literature review, statistical analysis and a survey of firefighters.

Stage two of the project will commence shortly and will firstly require the definition of typical fire loads and types in the 1970's and now and then to carry out an experimental study on typical rooms to map fire initiation and growth. Specifically CSIRO will conduct four room fire experiments on furnished single rooms at the CSIRO facilities at Highett in Melbourne. The room types and contents will be designed to examine the fire behaviour of existing soft furnishings and electrical and electronic equipment, both new and thirty years old. The objective is to compare fire initiation and growth in rooms containing a modern fire load with rooms containing an older fire load.

The room will be instrumented to measure heat release, temperatures and radiation. Carbon monoxide and carbon dioxide in the exhaust gases will be measured continuously.

3. Finding, results, outcomes…so far.

3.1Literature review

The stage one literature review set out to establish the current level of knowledge regarding the changes over a thirty year period in building design structure and furnishings and contents that may influence changes in levels of fire safety of residential building, in particular class 1a houses.

It found that while information was available regarding most other classes of building, data regarding houses and contents were not as plentiful and what was available did not conclusively prove or disprove the hypothesis. However what was found did resonate with FIRU case study research indicating that in some cases changes to construction practises and modern contents and furniture may have influenced the way fires develop in Class 1a dwellings.

For example, the National Institute of Science and Technology (NIST) Smoke Alarm Report (Bukuwksi, 2004) considered the performance of smoke alarms rather then houses and contents; however the study necessitated carrying out a series of test burns mimicking studies carried out in the 1970s. These tests highlighted that escape times were systematically shorter than those found in a similar study conducted in the 1970s. This is related to a combination of faster fire development times for today's products that provide the main fuel sources for fires, such as upholstered furniture and mattresses.

This report was interesting in that these tests were carried out originally in 1975 and then again almost 30 years later. One notable result was that test fires using a piloted flaming combustion reached 65° C at ceiling height on average in 130 seconds as opposed to an average of 970 seconds in the 1975 tests. This is a reduction from 16 minutes to 2 minutes within the room of origin of the fire. This is important as it has long been considered that, on average a fire will not flashover[1] and break out of the room of origin for at least seven minutes under average conditions. This study also highlighted that with a reduced escape time due to modern furnishings and contents, a working well placed smoke alarm may not be enough to guarantee survival.

The report summary advises "in many cases, available escape time would be sufficient only if households follow the advice of fire safety educators, including sleeping with doors closed while using interconnected smoke alarms to provide audible alarm in each bedroom, and pre-planning and practicing escape so as to minimize pre-movement and movement times during egress" (p.236).

In a study of how furniture contributes to fatalities in fires, Wong (2001) found that "the fire performance of individual furnishing items have a crucial effect on the swiftness of a room becoming

[1] Flashover describes a fire phenomena in which all the combustible material in a room reaches ignition temperature and ignites, leading to a rapid temperature rise and smoke and flame breaking out of the room of fire origin.

untenable thereby preventing further evacuation of occupants within the building" (p.111). Furthermore she found that a single piece of upholstered furniture is able to yield a fire severe enough to result in flashover of a compartment. Wong also highlights that the contents of typical New Zealand households where the study was conducted, has changed considerably with the use of modern materials. This trend has been most notable in upholstered furniture with the use of cheaper and more durable synthetic materials.

Closer to home in an Australian study, Dowling et al (1991) undertook research on fires starting in fully made up beds. The mattresses contained various foams and were ignited by smoldering or flaming sources. Fires started by igniting crumpled sheets lead to total involvement of the bed in all cases regardless of whether the foam was fire retarded polyurethane or latex rubber foam.

Still in Australia, Webb et al (1999) reported on room fire experiments in which a small room contained an upholstered armchair went to flashover in 4 minutes. The armchair used consisted of non fire retarded polyurethane foam.

3.2 Statistical Analysis

Data was accessed from various sources including, Australian Bureau of Statistics (ABS) , National Coronial Information System (NCIS), Australian Institute of Health and Welfare (AIHW) and the Australian Incident Reporting System (AIRS) as used by fire services. There are a number of limitations in comparing data from these sources. Definition of fire related deaths and fire injuries vary between sources and AIRS data can be dependant on information available to the fire service officer at the time. In addition the AIRS system relies on the fire officer's level of training, knowledge of fire science and experience in reporting on fires to accurately record what has happened. Despite its limitations AIRS data provided the best time line data and thus was used for this particular report.

AIRS data sourced in regard to injuries and fatalities in NSW indicated that;

- The annual rates of fatalities per 1,000 building fires and fatalities per 1,000 dwelling fires has increased each year consecutively since 2000 till 2005
- The annual rates of fatalities from building fires per 100,000 population and fatalities from dwelling fires per 100,000 population has also slightly increased each year since 2000 till 2005
- There has been a general upward trend in annual rates of injuries from building fires and dwelling fires per 100,000 of population, and

In relation to building and dwelling fires the AIRS statistics indicated that there had been a general downturn trend in the number of building and dwelling fires per 100,000 population over the past three decades however the decline in building fires had been steeper than the decline in dwelling fires.

Dwelling fires accounted for 47% of the total building fires in New South Wales between 1974 and 2005, and flats, units and other residential types accounted for an additional 17%. The data between 1974 and 2005 also shows that:

- The percentage of structure fires occurring in Class 1a buildings appears to have been slowly decreasing since 1995;
- The percentage of structure fires occurring in residential buildings other than class 1 has almost double since 1974; and
- The percentage of structure fires occurring in shop, store, office buildings or storage have decreased since 1974.

Some caution is required when it comes to interpreting time series for confinement rates of fire to object or room of origin. There have been a number of changes to definitions and coding schemas between 1974 and 2005. In 1997 significant data collection changes were implemented and a new category for small structure fires was introduced. Since the change in data collection in 1997 small structure fires are not given a classification for extent of flame damage.

For this analysis it was assumed that small fires are almost always confined to the object, and hence were added to the confinement fires categorised within the object of origin.
Some general observations of the data show that:

- there was a general downward trend in confinement rates between 1974 and 1994 for building fires, however since about 1996 the rates have increased;
- there was a general downward trend in confinement rates between 1974 and 1994 for dwelling fires, however since about 1996 the rates have increased;
- since 1999, the majority of building fires (80%) have been confined to the object, area or room of origin;
- since 1999, just over half of building fires have been confined to the object of origin, and
- in the past six years the majority of dwelling fires (78% - 80%) have been confined to the object, area or room of origin.

3.3 Survey of firefighters

The NSW Fire Brigades designed a questionnaire to be completed by experienced NSWFB firefighters. The survey was completed by 85 participants with the focus on utilising fire fighters who had attended a large number of house fires over a 10-20 year career or fire fighters who had been exposed to house fires over a 20+ year career.

The strength of this report lies in the information provided through statistics gathered from a widely experienced group of fire fighters from all over NSW. Over 96% of respondents had over 10 years experience and 48 % of those had in excess of 20 years service. An estimated 10,000 house fires had been attended by the respondents.

From the questionnaire's findings, over 75% of firefighters believed that the risks to firefighters had increased because of changes in the construction, design layout and contents of houses. Almost 50% believed that modern house fires were taking longer to bring under control due to the fuel loads within and the type of construction. Another important finding was that over 80% of respondents believed that the structural stability was lower in modern style houses during fire incidents.

The last two questions required the respondents to recall house fires they had attended and the responses reinforced the anecdotal evidence that had been observed over the past few years. The issues such as lightweight construction, air conditioning ducting, open plan design, lack of compartmentation, and household furnishings all ranked highly in having a significant impact on fire spread and structural integrity.

Other specific issues raised by the firefighters included I-beams, expanded polystyrene (EPS) cladding, and heating ducts.

In addition, 61% of senior NSWFB firefighters interviewed as part of this study believed that modern security measures such as deadlocks and security screens directly contributed to injuries and fatalities at house fires.

3. Conclusion

The literature review indicated that the changing nature of housing contents was having an impact the time it took for experimental fires to flashover and would thus support the hypothesis that modern furniture and increased fire loads is leading to fires that have a higher and faster heat release rate then was previously the case. However the statistical information in regard to fire fatalities and injuries does not support the hypothesis and the statistics on confinement of fire are inconclusive. It may be that other factors such as fire education programs, smoke alarms and escape plans may also be having an influence on death and injury rates. Additionally, confinement rates for residential fires in

particular, must be influenced by factors such as smoke alarms, improved training and better placement of fire stations.

The survey of firefighters did support the hypothesis and would indicate that apparent risks to firefighters had increased because of changes in the construction, design layout and contents of houses. Once again modern training methods and improved protective uniforms and equipment may be balancing out any increased risk from changing operating environments for firefighters

The overriding conclusion of stage one of the joint CSIRO / NSWFB project was that there was insufficient information available to comprehensively compare over a thirty year period, the impact of changes in individual factors such as building design, construction, furniture and contents. While the report could not prove that modern house fires are increasingly dangerous, it could not disprove the possibility either. It may be that case study research by FIRU, perceptions of firefighters and some experimental research is pointing to an emergent trend that has yet to register as fatalities, injuries and confinement rates. Or it may be that increasing risk from domestic environments is being balanced by fire education campaigns, smoke alarm legislation and improved capabilities of firefighters. While stage one established the context and levels of existing knowledge, Stage two of the project will involve experimental burns aimed and proving or disproving the hypothesis at least in the experimental context. Beyond this there is a continuing need for further research to identify any emergent trends and the general impact of fire on the community. Likewise there is a continuing need for research into the effectiveness and impact of fire safety programs if fire services are to continue improving community resilience to disasters such as fire.

4. Acknowledgements

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