Fire Research Report

What impact has the change in building materials and design in housing had on the cost damage of fires?

BRANZ

February 2010

Changes in materials and design of housing over the years were examined and tested for the relationship, if any, to fire incidence. The main finding was that the incidence did not change greatly by age of house for most houses constructed last century. However, the severity of fire was slightly greater in pre-1945 houses compared to more recent houses. Also, houses with wood based materials including weatherboard cladding and hardboard/timber sarking linings had more severe fire damage than brick clad and plasterboard houses. Design trends identified since the 1960s include more upper storeys, open plan layouts and attached garages. These features tend to increase the fire risk but are off-set by more fire resistant claddings and linings, and safer electrical wiring and fittings in the younger housing stock. Analysis of the fire service data indicates that failures in fixed equipment (stove, heaters, wiring, switch and light fittings etc) accounts for only about 30% of fires and the rest are due to adverse occupant behaviour (incorrect use of heaters and stoves, cigarettes, lighters, candles etc). This suggests the importance of better understanding how people use houses and the importance of early detection and containing fire spread.

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Housing design changes and fire damage

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Housing design changes and fire damage

1. CLIENT

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2. INTRODUCTION

This report examines the house design factors affecting fire damage suffered by detached houses in fires. The sources of data includes the NZ Fire Service fire incidence database i.e. their Station Management System ((SMS) database, the BRANZ House Condition Surveys (HCS) (Clark et al, 2005), and the Quotable Value New Zealand housing database. Architects and fire engineers were also consulted. The aim of the work is to investigate how changes in house design and materials over the years may have affected the amount of fire damage in housing.

3. SUMMARY

The SMS database records house age by 6 groups and the number of fires and fire incidence is shown for a selected period of fires from the database, see Table 1.

Table 1 Fires by house age group

Fire incidence by house age			
Years built	Houses built (1) (000)	Number of fires (2)	Number of fires per 10,000 houses, per year
Pre 1900	6	138	26
1900 - 1945	250	1972	9
1946 - 1969	440	4170	11
1970 - 1991	370	3668	11
1992 - 2005	276	1091	4
2006 onwards	64	52	1
Unknown		633	
All ages	1406	11724	9

(1) QVNZ, Census 2006, Stats NZ, BRANZ estimate of new houses.
(2) SMS database July 2000 to April 2009.

For houses built between 1900 to 1991 the incidence is very similar, at about 10 fires per 10,000 houses per year. Houses after 1991 have a quite low incidence, at about 4 fires per 10,000 houses per year. The appendix describes how the total stock numbers were derived by age group.

The SMS records the extent of damage as a percentage of the property saved (based on the floor area of flame damage). In this report less than 20% saved is arbitrarily assigned as a "high" severity fire and more than 80% saved is assigned "low" severity. Table 2 indicates that older houses, i.e. pre-1946, are more likely to be more severely damaged in a fire than younger houses. There is some indication from the table that damage severity increases again slightly for houses built after 1991.

Table 2 Damage severity by house age

Severity of fire by house age					
Years built		Percentage of fires by severity (1)			
		High	Medium	Low	Total
Pre 1900		27	29	44	100
1900 - 1945		19	23	58	100
1946 - 1969		15	22	63	100
1970 - 1991		12	20	68	100
1992 - 2005		14	19	68	100
2006 onwards		15	23	62	100
All ages		15	21	64	100
(1) Severity is defined as the % of property saved (from SMS).					
	Severity=	High	Medium	Low	
	Property saved %=	0-20%	21-80%	81-100%	

Fire incidence in housing is affected by housing characteristics and occupant behaviour. It is estimated in the report that about 30% of fires are due to failure of fixed equipment (stove, wiring, power and light fittings, and heaters), and the rest are due to inappropriate behaviour by occupants and consumer equipment failures.

Housing characteristics relevant to fire incidence trends include design and material changes through the years. Design changes have included open-plan, more upper storeys, and larger windows in later houses. They enable the fire to spread more easily. Modern houses are larger than older houses, have attached garages, and in the 1970s and 1980s often had solid fuel heaters with inadequate clearances. Larger houses have more bedrooms and hence more likelihood of fires starting unobserved. Garages are commonly used for storage and in the event of ignition the fire readily spreads to the house.

Off-setting these design trends are changes in materials and equipment which tends to reduce the fire risk. Timber claddings, ground floors and linings are now much less common than in earlier houses, thereby reducing fire risk. Old electrical wiring which becomes brittle and causes electrical fires was replaced with durable plastic coated wiring from the 1950s onward. Open fires, and solid fuel heaters to some extent, are being phased out and replaced with heat pumps which are generally safer.

The net effect of changing design and material trends is that fire incidence has been fairly constant across the decades at about 10 fire per 10,000 houses per year. However post-1991 houses appear to be significantly safer and this is due to a combination of better performance of materials and fixed equipment, and apparently “better” behaviour by occupants in these houses compared to those in earlier houses.

4. MAIN RESULTS

4.1 Location and causes of fire in houses

Four of the SMS data fields relating to fire origin and objects affected were examined. These data fields, and the questions asked, were as follows:

- Room of fire origin (i.e. have changes in house layout affected fire risk?)
- Heat source for the fire (is it building related or occupant caused?)
- Equipment (if any) involved in the fire (is it building or consumer equipment?)
- Object first ignited (have changes in material types affected fire risk?)

Table 3 indicates that the kitchen is the main area for fires, followed by the family room, and bedrooms. Roof spaces, walls and garages are next in incidence of fire origin. The incidence for kitchen fires increases after 1945 and the reason is not known but it may be related to the types of appliances (i.e. stoves), discussed later.

Fire incidence in bedrooms and garages increases with reduced age of house. This may reflect an increase in the number of bedrooms as houses have got bigger over the years, and hence have an increased likelihood of fires in bedrooms. Roof space fires are mainly due to defects in chimneys and flues. Roof fires occur at a quite high level for all age groups up to 1991. In older houses the defects are in brick chimneys, and in more recent houses the fires have been caused by corroding steel flues.

The rising incidence in garages may reflect the increase in attached garages in new houses, particularly after 1960. Garages have become larger over the years with more storage space and are more likely to have combustible materials such as liquid fuel.

Table 4 has the heat source in fire incidences and indicates that building fixed items (solid fuel/ open fires, wiring and short circuits) are responsible for about 33% of known fire sources. Also, the electrical equipment group, which is the most common fire source, includes stoves and fixed panel heaters. So about 40% of the heat source is related to the building services items, and the other 60% to consumer appliances (electronic appliances) or occupant behaviour (matches, cigarettes, etc).

Table 3 Location of fire origin

Location of fire origin House fires between July 2000 to April 2009							
	Fires per 10,000 houses per year						
Heat source	House age					2006	
	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005	onward	All ages
Kitchen	3.6	1.8	2.6	2.8	1.0	0.1	2.20
Lounge/ family room	6.1	2.1	2.3	2.0	0.7	0.1	1.90
Bedroom	3.1	1.3	1.8	2.2	0.8	0.1	1.61
Ceiling/ roof	3.3	0.7	0.8	1.0	0.5	0.2	0.78
Wall surface (exterior)	2.5	0.9	0.9	0.7	0.3	0.1	0.74
Garage/ shed	0.8	0.2	0.6	1.0	0.5	0.1	0.63
Wall space	2.5	0.5	0.4	0.3	0.1	0.1	0.36
Storage/ tool room	0.6	0.2	0.2	0.2	0.1	0.0	0.17
Laundry	0.2	0.1	0.2	0.2	0.0	0.0	0.15
Toilet	0.0	0.1	0.1	0.1	0.1	0.0	0.13
Patio/ gazebo	0.0	0.1	0.1	0.1	0.1	0.0	0.11
Hallway	0.8	0.1	0.1	0.1	0.0	0.0	0.08
Entrance/ lobby	0.0	0.1	0.1	0.1	0.0	0.0	0.06
Balcony/ deck	0.4	0.1	0.1	0.1	0.0	0.0	0.06
Subfloor/ basement	0.4	0.0	0.1	0.0	0.0	0.0	0.05
Other	1.2	0.3	0.3	0.3	0.1	0.1	0.31
Unknown	1.2	0.1	0.1	0.1	0.0	0.0	0.10
Total	26.5	8.9	10.7	11.2	4.5	0.9	9.4
Source: SMS, House fires between July 2000 to April 2009							

Table 4 Heat source for fire

Heat source House fires between July 2000 to April 2009							
	Fires per 10,000 houses per year						
Heat source	House age					2006	
	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005	onward	All ages
Electrical equip. Incl stoves	2.1	1.4	2.1	2.5	0.8	0.1	1.8
Solid fuel/ open fire/ radiator	6.0	1.4	1.7	1.7	0.6	0.1	1.4
Lighter/ match	3.5	1.1	1.4	1.5	0.5	0.2	1.2
Short circuit in wiring	2.1	1.0	1.2	1.3	0.6	0.1	1.1
Cigarette	1.3	0.4	0.5	0.5	0.1	0.1	0.4
Candle	0.6	0.2	0.3	0.3	0.2	0.0	0.3
Short circuit in equipment	0.8	0.2	0.2	0.3	0.1	0.0	0.2
Electric lamp	0.2	0.1	0.1	0.2	0.1	0.0	0.1
Other	5.8	1.8	2.0	2.1	1.1	0.2	1.8
Unknown	4.2	1.2	1.1	0.9	0.4	0.1	1.0
Total	26.5	8.9	10.7	11.2	4.5	0.9	9.4
Source: SMS, House fires between July 2000 to April 2009							

Table 3 and Table 4 suggest that cooking accidents are a major cause of fires in houses, and Table 5 confirms that as stoves and ovens head the list. The table has a large "not recorded" category so it is not known if equipment is involved with those fires. However, if the building services items are summed (stove/ oven, fixed heater, bulbs, solid fuel heater, meter, light fixtures, wall switches, power outlets hot water cylinder, and cabling) the total is 2.0 fire per 10,000 houses over the 8 year period. This is about 40% of recorded incidences so that about 40% of all residential fires are building fixtures related (i.e. stove, fixed heaters, meter, cabling, and hot water cylinder), confirming the results from the heat source table.

Many of these fires will be due to defects in fixtures, but for the stove and panel heaters some fires are due to inappropriate use by occupants (e.g. burnt food on hot plates, clothes placed on electric or solid fuel heaters, etc). So the share of all fires attributed to physical failures in the building services fixtures (oven, wiring, lighting, switches, power outlets, fixed heaters, hot water cylinders) will be less than 40%.

Original stoves are likely to have been replaced for pre-1945 houses but houses from 1946 to the 1970s may still have the original stoves, many in a state of deterioration, hence an increase in kitchen fires after 1945. This is suggested in Figure 1 where 1940s to 1960s houses have stoves in the worst condition.

Table 5 Equipment involved in the fire

Equipment involved in fires							
House fires between July 2000 to April 2008							
			Fires per 10,000 houses				
	House age					2006	
	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005	onward	All ages
Stove & oven, electric /gas/ solid fuel.	1.92	0.67	1.21	1.46	0.48	0.02	1.04
Fixed heater -not specified	0.77	0.19	0.21	0.25	0.09	0.02	0.20
Halogen and indenscent bulbs	0.38	0.10	0.16	0.27	0.14	0.00	0.18
Portable spaceheaters	0.38	0.14	0.21	0.15	0.05	0.00	0.15
Solid fuel heater	0.19	0.08	0.19	0.19	0.04	0.02	0.14
Electric blanket	0.00	0.10	0.13	0.21	0.06	0.00	0.13
Meter	0.38	0.13	0.14	0.12	0.02	0.02	0.12
Clothes dryer: Residential	0.19	0.10	0.11	0.11	0.06	0.00	0.10
Incandescent light fixture	0.19	0.06	0.08	0.13	0.05	0.00	0.09
Wall switch/ power outlet	0.19	0.06	0.06	0.10	0.07	0.04	0.07
Television	0.19	0.06	0.07	0.10	0.05	0.00	0.07
Electric water heater	0.19	0.09	0.07	0.08	0.02	0.00	0.07
Toasters	0.00	0.05	0.04	0.07	0.08	0.00	0.06
Cabling	0.19	0.06	0.06	0.06	0.02	0.00	0.05
Multi plug box	0.00	0.05	0.05	0.06	0.02	0.00	0.04
Dishwasher	0.00	0.05	0.02	0.06	0.05	0.02	0.04
Other equipment	3.07	0.96	0.99	1.32	0.62	0.18	1.03
No Equipment Involved in Ignition	5.18	1.71	1.85	1.79	0.70	0.41	1.60
Not recorded	13.05	4.29	5.06	4.68	1.87	0.21	4.26
Total	26.5	8.9	10.7	11.2	4.5	0.9	9.4
Source: SMS, House fires between July 2000 to April 2009							

The objects first ignited are shown in Table 6 and the most common are framing, cooking food, wiring, wall claddings, bedding and wall linings. Framing, wall claddings and linings ignition incidence is high for the pre-1900 houses, reflecting the predominance of timber in these elements.

In summary, Table 1 to Table 6 indicates that pre-1900 houses have the highest fire incidence, and between 1900 and 1991 the incidence is lower and fairly constant across the decades. After 1991 the incidence falls again. Less than 40% of the fires are due to failures in the building fixtures and services and the rest are due to occupant behaviour. The actual percentage of fixture failures, rather than incorrect use of equipment, is uncertain but a “guesstimate” is that about 30% of fires are due to failures in the fixtures. These are unsafe stoves and fixed heaters (solid fuel and electric panel heaters), unsafe hot water cylinder wiring, old circuit wiring, unsafe light switches and fittings, faulty power outlet fittings, and unsafe flues and chimneys. Generally the incidence of these faults are higher in older houses.

Table 6 Object first ignited by fire

Object ignited							
			Fires per 10,000 houses per year				
Obljected ignited	House age					2006	
	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005	onward	All ages
Framing	4.4	1.1	1.2	0.9	0.4	0.1	1.0
Cooking materials, food	1.0	0.5	1.1	1.3	0.4	0.0	0.9
Electrical wire, Wiring insulation	1.5	0.7	0.9	1.1	0.4	0.1	0.8
Exterior wall claddings	3.3	1.2	0.9	0.6	0.4	0.0	0.8
Bedding eg. Mattress, Pillow	0.8	0.4	0.8	0.9	0.3	0.0	0.6
Interior wall covering	2.3	0.6	0.6	0.5	0.2	0.1	0.5
Furniture (beds, chairs, sofas)	0.8	0.4	0.5	0.6	0.2	0.0	0.5
Flammable liquids	0.4	0.2	0.4	0.4	0.1	0.1	0.3
Clothing (Not being worn)	0.4	0.2	0.3	0.4	0.1	0.0	0.3
Rubbish, Garbage, Waste	0.8	0.3	0.3	0.3	0.1	0.0	0.2
Exterior roof claddings	0.4	0.1	0.1	0.1	0.1	0.0	0.1
Thermal insulation	0.2	0.1	0.1	0.1	0.1	0.0	0.1
Other	7.5	2.7	3.1	3.6	1.6	0.4	2.9
Unknown	2.9	0.6	0.5	0.4	0.2	0.1	0.5
Total	26	9	11	11	4	1	9.4
Source: SMS, House fires between July 2000 to April 2009							

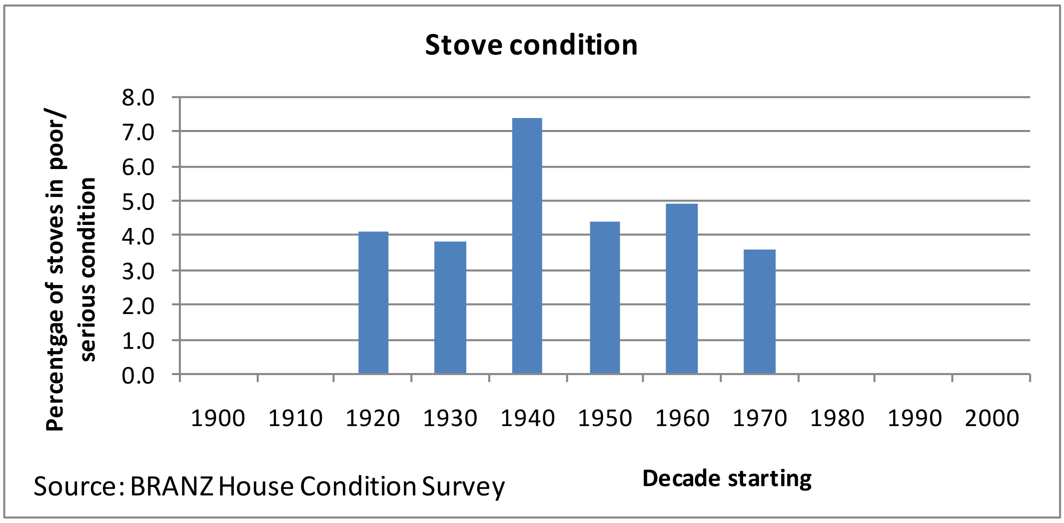

Figure 1 Stove/ oven condition by age group

4.2 Material types in housing

4.2.1 SMS materials data

The analysis so far has considered the location and causes of fire. This section examines the role of building materials on fire incidence and severity. Table 7 to Table 9 show results from the SMS for damage on some house components by material type. Houses with timber wall claddings suffer a higher percentage of severe fires than other cladding types. In kitchen and lounge/ family room fires the extent of damage is larger with timber based linings, compared to plasterboard linings.

Table 7 Severity of fire damage by wall cladding type

Severity of damage by wall cladding material					
Cladding type	Percentage of fires by severity				Sample
	High	Medium	Low	Total	size
Brick, concrete masonry	3	7	90	100	29
Fibre cement sheet/ planks	3	20	78	100	40
Stucco	0	24	76	100	25
Weatherboard (timber)	13	22	65	100	279
Other	15	11	74	100	47
All	11	19	70	100	420
Other = steel, PVC weatherboards, EIFS, etc.					
Source: SMS database, only 420 records have claddings data.					
Severity is defined as the percentage of property saved.					
Severity=	High	Medium	Low		
Property saved % =	0-20%	21-80%	81-100%		

Table 8 Severity of kitchen fire damage by wall linings type

Severity of damage by wall lining material for kitchen fires						
Lining type		Percentage of fires by severity				Sample
	Severity =	High	Medium	Low	Total	size
Fibrous plaster		8	16	76	100	111
Gypsum board		8	15	76	100	1875
Wood reconstituted sheet		19	23	58	100	303
Timber sarking & panelling, Pinex.		25	30	46	100	287
Other		19	21	60	100	107
All		12	18	70	100	2683
Other = combination of linings, concrete, brick, fibre cement sheet & steel.						
Source: SMS database, House fires between July 2000 to April 2009						
Severity is defined as the percentage of property saved.						
	Severity=	High	Medium	Low		
	Property saved % =	0-20%	21-80%	81-100%		

Table 9 Severity of lounge/ family room fire damage by wall linings type

Severity of damage by wall lining material for lounge/ family room fires						
Lining type		Percentage of fires by severity				Sample
	Severity =	High	Medium	Low	Total	size
Fibrous plaster		11	25	64	100	126
Gypsum board		14	24	62	100	1480
Wood reconstituted sheet		28	20	52	100	210
Timber sarking & panelling, Pinex.		38	27	34	100	331
Other		18	31	51	100	108
All		19	25	57	100	2255
Other = combination of linings, concrete, brick, fibre cement sheet & steel.						
Source: SMS database, House fires between July 2000 to April 2009						
Severity is defined as the percentage of property saved.						
	Severity=	High	Medium	Low		
	Property saved % =	0-20%	21-80%	81-100%		

The SMS database does not have much additional data on materials and so the next section uses the HCS to assess materials types by age group in the overall housing stock.

4.2.2 HCS materials data analysis

Figure 2 to Figure 6 show material and other characteristics of the housing stock by age group, mainly derived from the HCS. The figures indicate that older houses are more likely to have timber claddings and floors, and also a higher incidence of old electric wiring and open fires. These characteristics are associated with an increase risk of fire damage.

In Figure 2 timber wall claddings predominate before 1940 while fire resistant claddings such as brick and fibre cement sheet start to come more common after 1940. Figure 3 indicate timber ground floors were common before 1960 but thereafter concrete slab floors increased rapidly as a percentage. Upper floors are now more usual in recent houses due to large houses and reduced section sizes, and these are usually particleboard floors. So while the ground floor is concrete many recent houses have some timber flooring, see Figure 4. The existence of an upper floor may also enable fire spread up the stair well.

The electrical wiring types are shown in Figure 5. Almost all houses now have the modern tough plastic sheathed cabling. But some houses still have some of the older rubber insulated wiring and these often pose a fire risk. Both rubber insulated wiring types, see Figure 5, become brittle with age, crack and cause short circuit fires. With more than one type the totals are over 100% for most age groups.

The SMS does not record the types of flooring, wiring, heating or the existence of upper floors so it is not possible to compare the materials types from the HCS for these components against the severity of damage. However, for older houses the existence in general of more timber cladding, timber floors, old wiring and open fires, compared to younger houses, partly explains the greater fire severity in older houses.

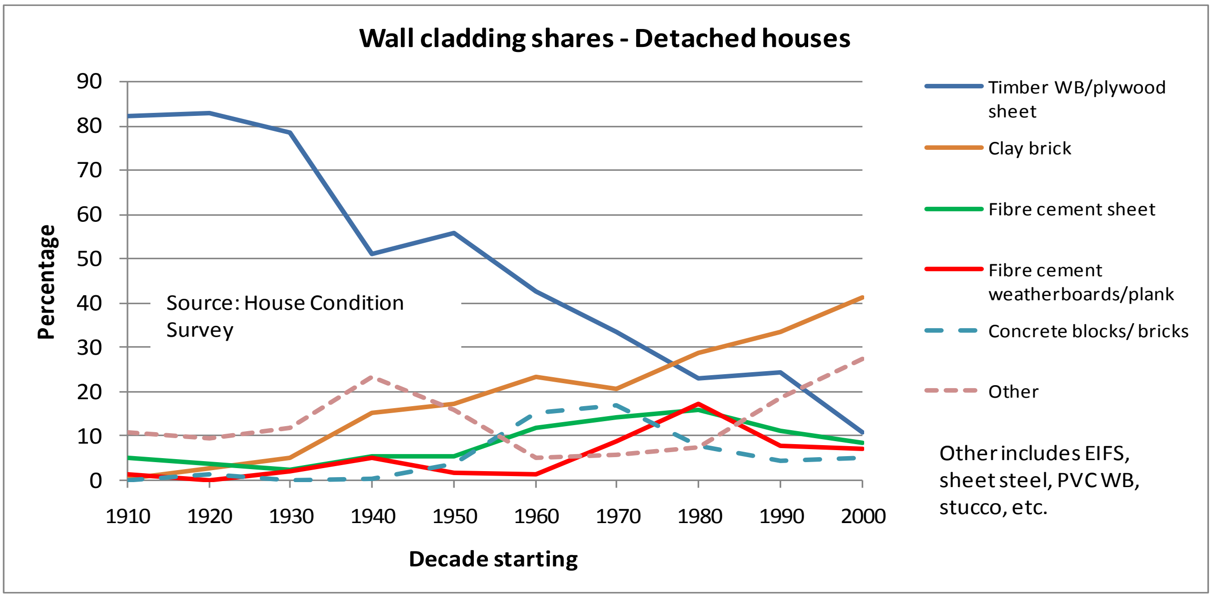

Figure 2 Wall claddings by age group

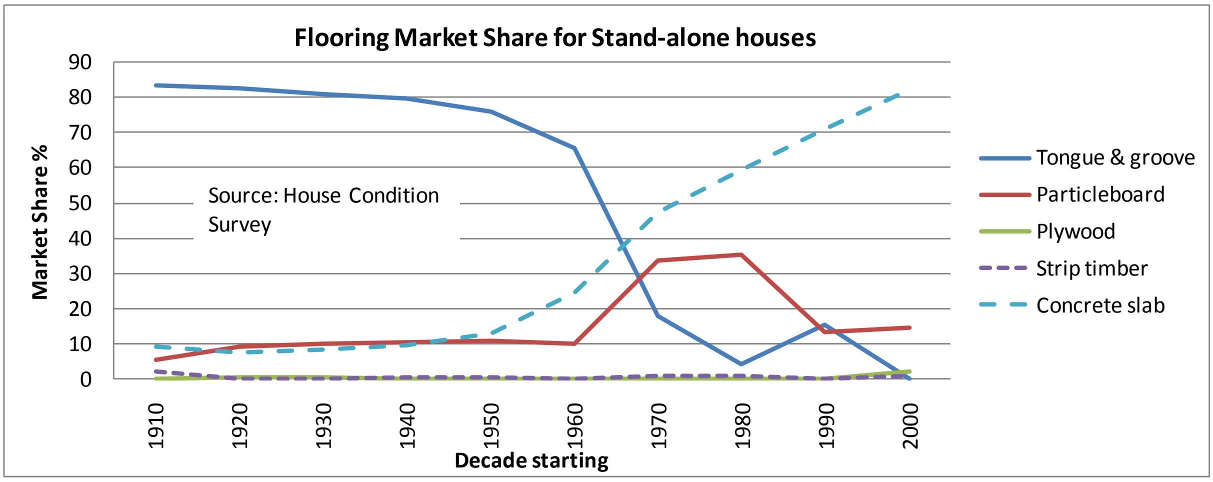

Figure 3 Flooring by age group

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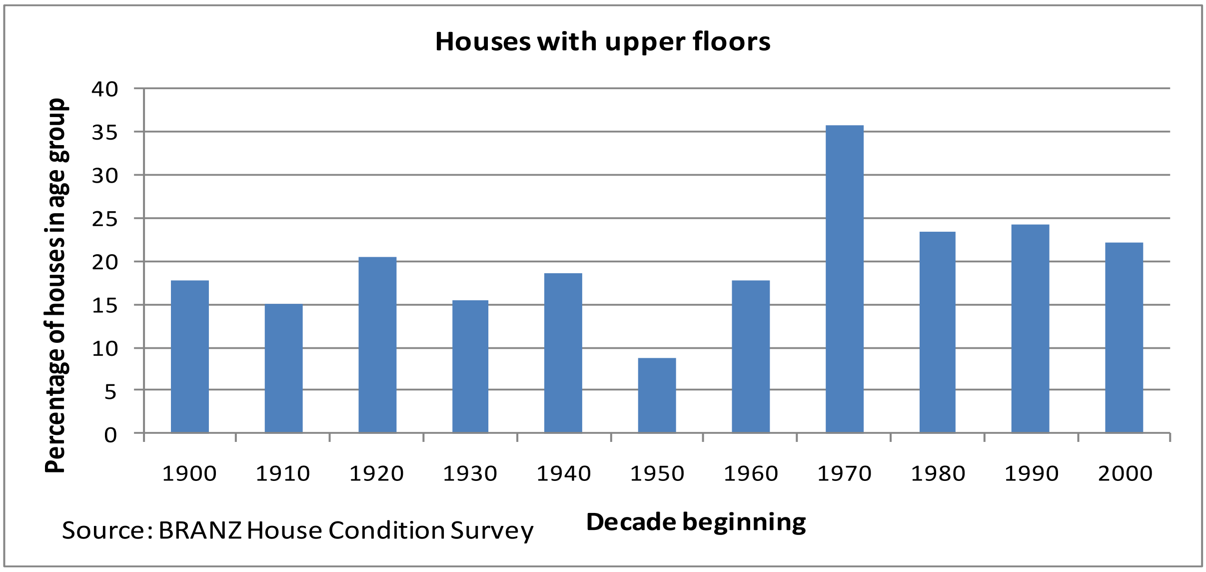

Figure 4 Upper floor incidence by age group

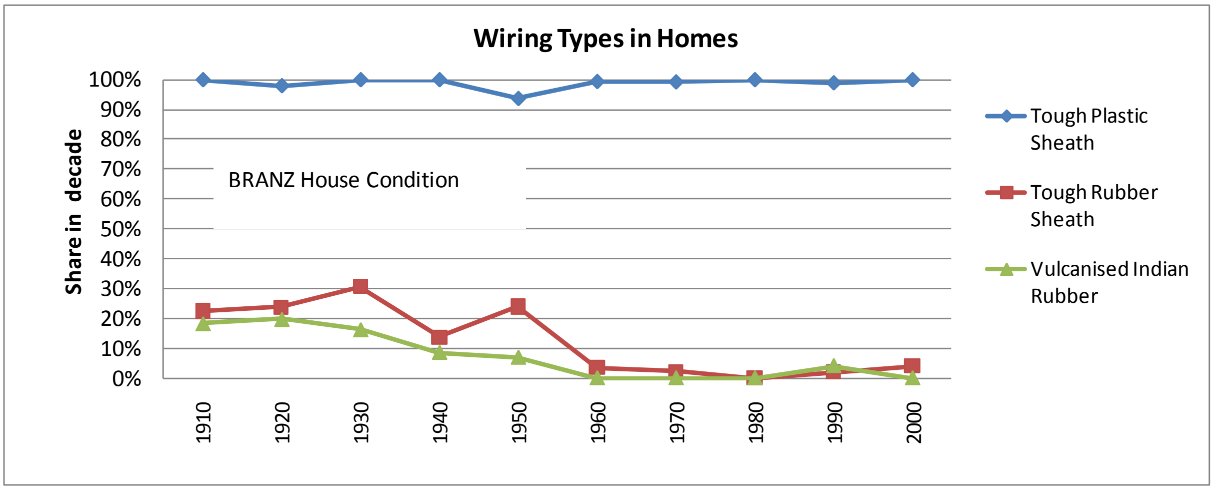

Figure 5 Electrical wiring types by age group

The incidence of chimneys is shown in Figure 6. Open fires have a high incidence in housing up to the 1960's. The existence of a chimney and fireplace does not necessarily indicate an open fire is used. However Figure 7 reports on space heating appliances, in use at least occasional, and suggest that a quite high proportion of these fire places are used for open fire heating.

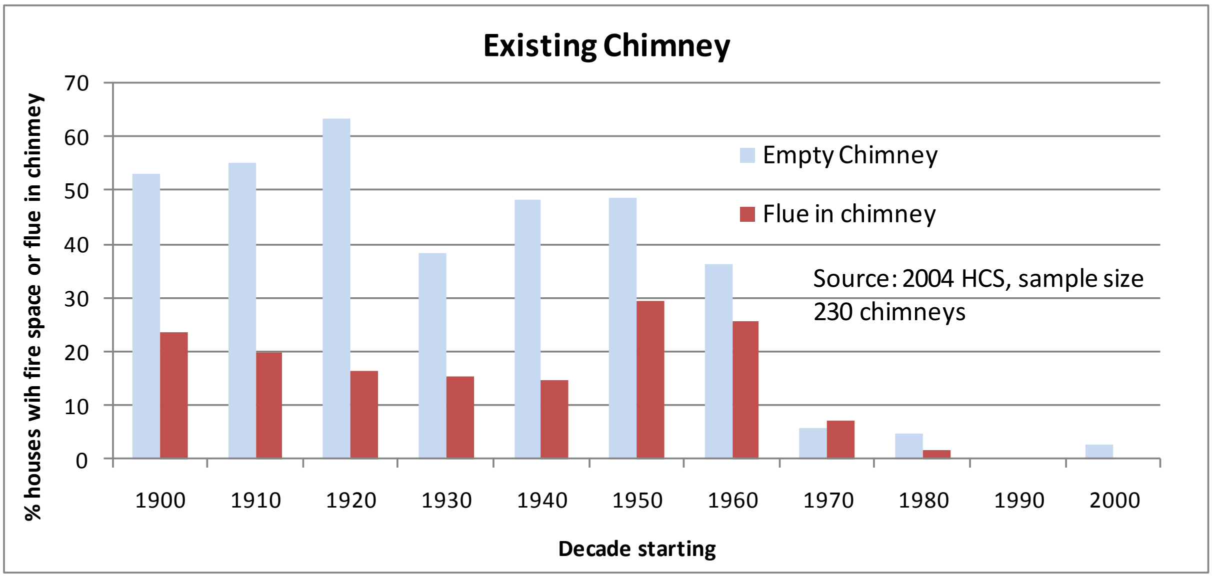

Figure 6 Chimney incidence by age group

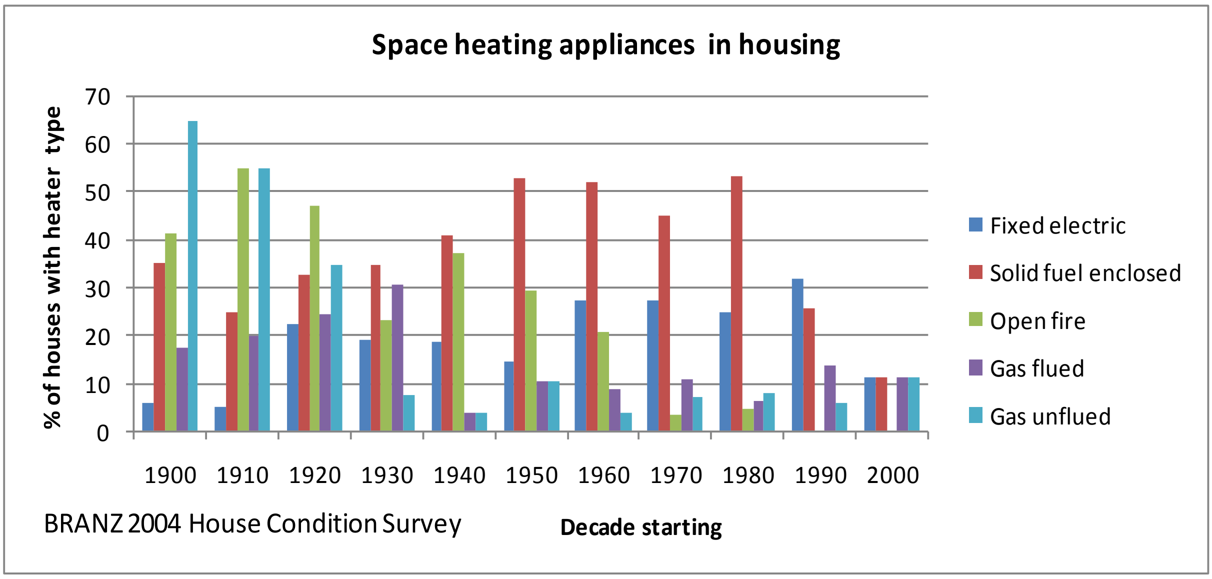

Figure 7 Space heaters by age group

The bars sets in Figure 7 add to more than 100% for some decades since houses can have more than one type of space heating appliance. Fixed electric includes heat pumps.

The average size of houses has been trending up since the 1950's, see Figure 8. The effect on fire damage is the larger houses contain more furniture and other contents providing more fuel in the event of fire, compared to the smaller and older houses. Hence the cost of repair for younger houses will tend to be higher than for older houses, given a similar severity of fire.

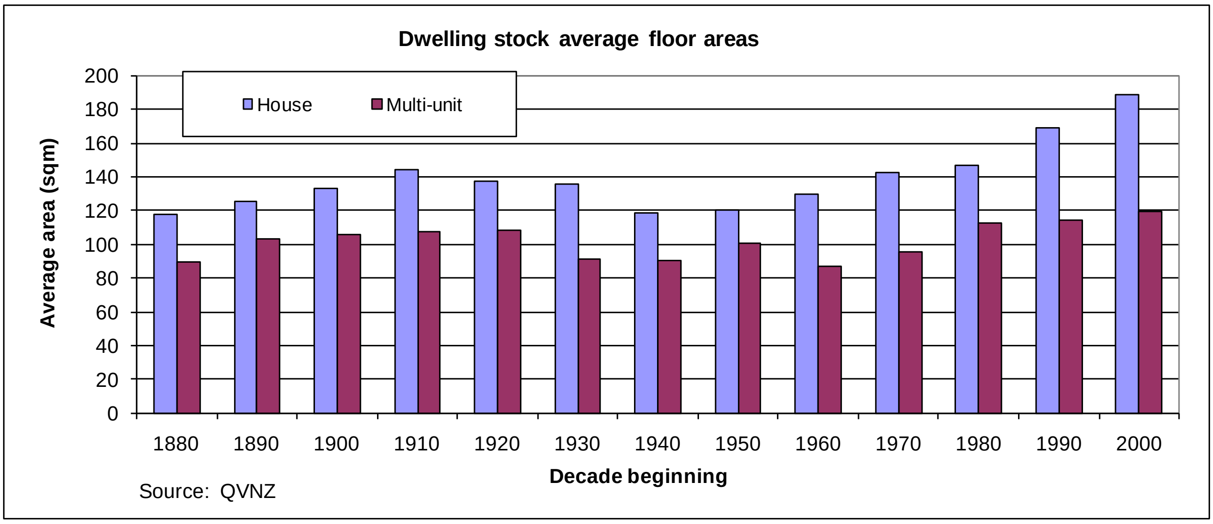

Figure 8 Average floor areas by age group

Window areas in houses are getting larger over time. Data from the Household Energy End-use Project (HEEP) (Isaacs et al, 2006) indicates this is fairly recent, i.e. only since the 1980s has the total window area increased, see Figure 9. It is uncertain what effect larger windows have on fire damage, though probably it facilitates fire spread, as discussed later, in the fire engineer interview.

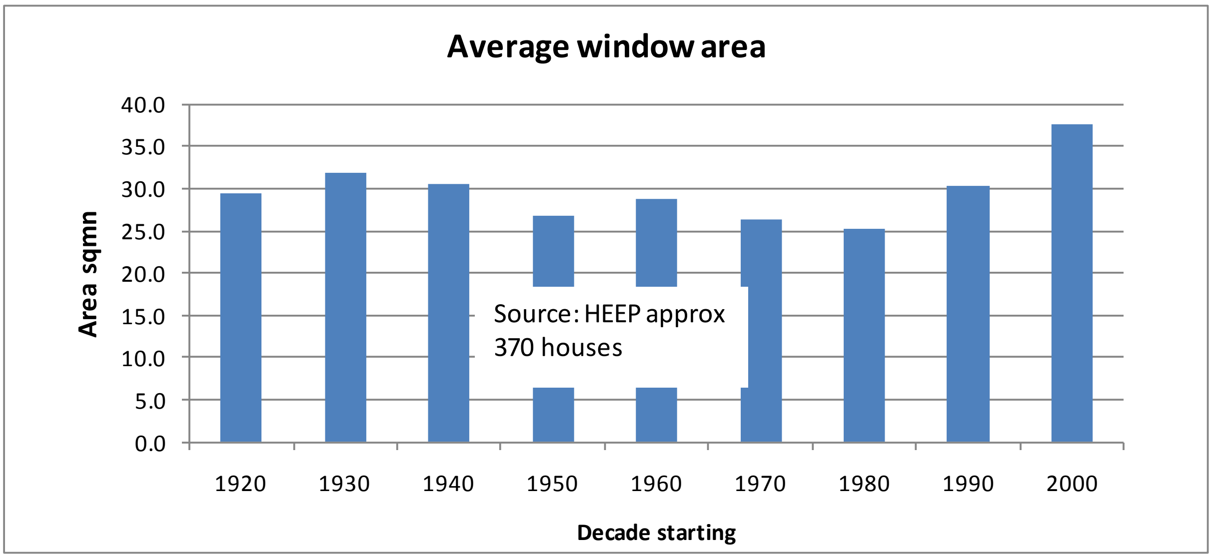

Figure 9 Window areas by age group

4.2.3 Materials analysis summary

Analysis of the materials and design characteristics from the SMS and HCS datasets indicates:

- Fire severity is higher in houses with weatherboard claddings and timber based linings, than with other materials. House built before 1950 are more likely to these materials. While the 1900 to 1945 group has a similar fire incidence to 1946 to1991 houses, their severity is higher.
- At least 10% of pre-1940 houses have some rubber insulated wiring, hence the quite high incidence of wall space fires in these houses.
- Open fires are more common in pre-1960 houses than later houses, and helps explain the high incidence of open fires as a cause, see Table 4. However, solid fuel heaters have been retrofitted into all age groups. Corroding flues and inadequate clearances with these heaters are one reason why these fires have a high incidence up to 1991, (see Table 5).
- The relative importance of upper floors and larger windows, compared to other causes, in residential fire incidence is not well understood. Both are likely to make fire damage more severe and may be one reason why severity increases for houses built after 1991, see Table 2.

5. QUALITATIVE ASPECTS OF DESIGN CHANGES

This section reports on discussions held with an architect and a fire engineering designer on trends in design and how these have affect fire risk in the residential sector.

To categorise design changes over the years a system of housing typologies was used, as in Table 10. The appendix describes the derivation of this table.

Table 10 Typology summary

Typology summary Numbers as at March 2006												
Number of dwelling units (000)												
Villas	Bungalow 1920-36	Art Deco 1925-40	Mass housing 40s-60s	Multi units Pre-1960	Multi units 1960-70s	Mass housing 1970-78	Housing 1978-80s	Multi units 1980-90s	Housing 1990-96	Housing post 96	Multi units 2000s	Total
86	113	18	479	34	133	151	182	68	112	201	28	1606

5.1 Architects response

Points noted during the conversations were:

- Younger houses have more open-plan, after 1978 and more particularly the 1990s and 2000s. This facilitates fire spread and smoke damage.

- Older houses (Villas, bungalows and Art Deco) tend to have fewer power outlets, and sometimes have electrical overload as occupants plug in more devices, leading to increased fire risk. Older houses may still have the original switchboard with wire fuses and often these are over-sized fuses which enable overload in the wiring circuit with an associated fire risk.

- The earliest wiring was individual rubber sheathed wires installed in steel conduit. Most original wiring has been replaced but BRANZ inspections occasional finds examples and it tends to be unsafe due to deterioration. Cloth bound vulcanized rubber was introduced about 1922 and becomes brittle over time - it should be replaced where encountered. The next wiring type was the early PVC sheathed cable with a bare earth wire, introduced about 1950. It also deteriorates over time (the individual wire sheaths become brittle) and should be replaced. The modern Tough Plastic Sheath (TPS) was introduced in the 1960s and appears to perform well.

- Some older houses still have scrim and match lining which burns well, and covers mainly Villas and 1920-36 Bungalows. Also some older homes have open fires and coal ranges. Phasing out of fire places and chimneys reduces the fire risk.

- The trend to an upper half storey from the 1970s increases damage in the event of fire.

- Softboard is quite common on walls in 1940-50s houses and in ceiling tiles in 1960s-70 houses. It burns quite well.

- Solid fuel burners are not always well maintained, especially the flues, and hot gas can vent into the roof space causing fires. These first appeared in numbers in about 1970 in new housing, but have since been retrofitted to all age groups.

- More combustible claddings occurred with the introduction of EIFS with from about 1990 onward.

5.2 Fire engineer response

- There are no fire resistant design requirements for housing except near the boundary (and solid fuel heaters). EIFS claddings have an increased fire risk compared to conventional claddings.

- The trend to larger windows in modern houses is difficult to assess from the fire risk perspective. Larger windows enable easier venting and lower the fire temperatures, but the increased outside air- supply enables the fire to continue when it might otherwise be stifled through lack of oxygen. Windows do not usually fall out completely in fire but the larger areas enable more venting. Probably the combination of smaller rooms, more doors, and smaller windows restricts the fire spread in older houses compared to newer houses. Hence it is expected the trend to more open-plan and larger windows in modern houses increases the amount of damage in the event of fire.

- The trend to synthetic carpets, away from wool carpets, is adverse because the former burns better than the latter. Modern furniture is largely polyurethane foam based and increases the fire risk and fire load compared to the older style furniture with kapok filling. As furniture replacements occur a large part of the housing stock will have modern foam based furniture.

- Garages in modern houses are usually internal access, and often have fuel stored in the garage, (insurance policies limit the fuel volume to 5 litres but this is often exceeded), increasing the fire risk for the house. Attached and basement garages started to become common from the 1970s.

- In older houses with high studs the fire alarm is often installed on the wall and not at full ceiling height, which delays the alarm in the event of fire, resulting in more damage. This normally applies to older houses, i.e. Villas and 1920's Bungalows.

6. DISCUSSION

The incidence of fires is markedly similar across a broad era of housing, from 1900 to 1991, at about 10 fires per 10,000 houses in the total stock per year. The incidence for pre-1900 was estimated as being more than twice as large but there may be a significant error in this estimate since it is difficult to get an accurate number for the stock numbers for this era.

Changes in layout of housing since the early years include more floor area (i.e. more bedrooms, larger living rooms), upper storeys, open-plan, and attached garages. Table 3 indicates that bedroom and garage fire incidences trended upwards from early years, in line with layout trends discussed earlier. Kitchen fires also trended upward but this is difficult to relate to kitchen design trends unless it is assumed post-1945 houses tend to have original stoves in a deteriorating condition, whereas earlier houses have had replacement stoves.

Earlier work (Page, 2009) noted that smoke damage often causes extensive repair costs even when the fire is contained to a small area. Open-plan in post-1970 houses facilitates this smoke damage.

Offsetting the increasing fire incidence in kitchens, garages and bedrooms after 1945 is a reduction in wall surface and wall space fires in Table 3. This probably reflects replacement of old wiring in walls, and the shift away from timber claddings and linings to more fire resistant claddings.

Adverse occupant behaviour is a major cause of fires, estimated at over 60% of all fires with the less than 40%, (probably nearer 30%) due to failure of the fixed equipment, including failures in the wiring, light and power outlet fittings, stoves and space heaters. Solid fuel and electric radiator heaters are a significant part of the equipment failures and appear as a fire heat source in all age groups of housing, see Table 4 and Table 5. Stove fires are also a major heat source. Some of these fires are due to equipment failure but it is likely inappropriate occupant use of appliances plays a large part as well.

Furniture and bedding fires have trended upward since the early years possibly reflecting an increase in flammable materials and contents in recent houses. In contrast wall cladding fire incidence declines in younger houses, see Table 6.

In summary, there are a variety of design, layout, material and occupant behaviour trends occurring simultaneously, which appear to cancel each other, giving a near constant fire incidence rate for houses across most of last century.

After 1991 fire incidence drops and this is so for all fire origins, heat sources and equipment. Designers and builders have in recent years become more aware of fire hazards and how to design to reduce hazards so this may account for some of the drop. The incidence of fires due to solid fuel heaters and open fires is low for post 1991 houses, probably due to the upgrade in the NZ Standard 2918 in 1990. Also stoves are likely to be in reasonable condition for these houses, reducing the fire risk.

There may be occupant behaviour changes in newer houses, compared to older houses, giving a reduced fire risk. For example, Table 4 indicates a drop in matches, cigarettes and candles as a heat source in post-1991 houses. However, it is unknown how much of the reduced incidence in new houses (post 1991) is due to physical characteristics of the house and how much (if any) is due to the different behaviours of the occupants compared to occupants in older houses.

In any case over 60% of fires are due to adverse occupant behaviour equipment failure (wiring, fittings, fixed heaters, etc). This suggests the importance of a better understanding of how people use houses and the importance of early detection, and materials/ design selections to contain fire spread.

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8. APPENDIX

The appendix consists of the following

- Housing stock numbers by age group estimates.
- Detailed analysis of material types from the HCS databases.
- Detailed analysis of materials types in fires from the SMS database

8.1 Housing stock numbers

Housing stock numbers by decade of construction were derived from three main sources:

- Quotable Value New Zealand (QVNZ) database of individual houses.
- 2006 census of population and dwellings.
- Building consent data.

The QVNZ dataset is mainly used by territorial authorities for property valuation and setting of rates. It has records for about 80% of the housing stock in New Zealand and a higher percentage for detached housing. Data recorded includes address, floor area, decade of construction, attached or detached, land and capital value plus some data on cladding types and footprint. About 5% of the dataset has mixed or approximate age data. This unknown age group was proportional spread among the other age groups.

The census purports to cover the total housing stock except derelict houses, and includes unoccupied dwellings such as holiday and other second homes, deceased estate, and homes for sale or rent. It is the most reliable data available on housing numbers.

Building consent data collected by Statistics NZ has been reliable since about the mid 1960s, but before that data from many rural authorities was not always collected. After allowance for a small percentage of cancellation of consents, plus adjustments for some demolitions in the 1960s and 1970s cohorts, the series provides another source for the younger cohort numbers.

The QV data was used to get decade age profiles for the housing stock, which was scaled up to match the total numbers from the 2006 census of dwellings. The resulting numbers were checked against the adjusted consent numbers for the decades since 1960 and minor changes done for compatibility.

The net resulting numbers are shown in Figure 10.

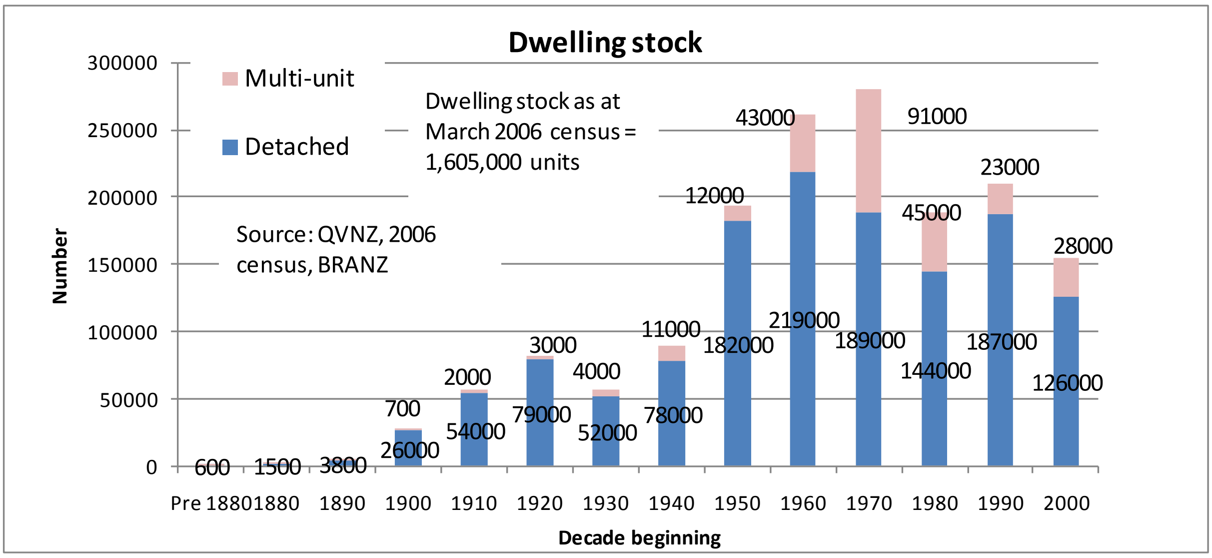

Figure 10 Dwelling stock by decade of construction

BRANZ knowledge of housing styles was used to approximately allocate the decades to housing typologies, see Table 11 Villas are the earliest group with significant numbers still existing, from pre-1900 to about 1920. They have weatherboard walls and corrugated sheet steel roofs, with some sheet steel on the walls. In the 1920s and early 1930's a bungalow style developed, the so-called California bungalow. These houses were mainly weatherboard and corrugated steel roofing. From the 1930s to the mid 1940s an Art Deco style was introduced, also from the USA consisting of stucco walls, and flat roofs (mathoid) with parapets. The 1940s to the 1960s was the era of the state house, solidly built often with brick cladding and concrete tiles, but weatherboard and sheet steel roofing are also common.

In the 1970s and 1980s designs became diverse, in clay and concrete brick, masonry block, weatherboard (cedar becoming common), and some fibre cement sheet. It is an era with little discernable style, and commonly includes upper storeys, basement garages, skillion roofs, and more complex floor plans. Concrete slab was introduced in the 1970s and by the end of the 1980s was in about 50% of new housing, with open-plan quite common. Monolithic cladding (stucco, fibre cement sheet, EIFS) occurs in about 40% of the 1990s houses. Other claddings becoming more common from 1980 included plywood sheet and PVC weatherboards.

The multi-units in Table 11 include a large number of state houses often of duplex design in the 1940s and 1950s. They have similar materials to the detached housing of the same era. By the 1960s and 1970s the linear single storey multi-units are common, and two storey multi-units with 4 to 8 occupancies in one building. From the 1990s on multi-units include terraced housing, and the so-called "town houses " of 2-4 adjacent units. Medium and high rise also appear in the 1990s in quite large numbers, some in quite poor conversions of former office space.

Table 11 Housing numbers by typology

House numbers by typology												
	Number of dwelling units to March 2006.											
	Dwelling unit numbers (000s)											
			Art	Mass	Multi	Mass		Multi			Multi	Total
Decade		Bungalow	Deco	housing	units	housing	Housing	units	Housing	Housing	units	
start	Villas	1920-36	1925-40	40s-60s	1960-70s	1970-78	1978-80s	1980-90s	1990-96	post 96	2000s	
pre-1900	6											6
1900	26											26
1910	54											54
1920		71	8									79
1930		42	10									52
1940				78								78
1950				182								182
1960				219	43							262
1970					91	151	38					279
1980							144	45				189
1990								23	112	75		209
2000										126	28	155
Total	86	113	18	479	133	151	182	68	112	201	28	1572
								Pre 1960s multi-unit numbers =				34
								Total all dwelling units (000) at 2006 =				1606

8.2 House Condition Survey material types

The HCS is a condition survey of approximately 500 houses in the three main centres, carried out in 1999 and 2004. Material types for over 30 building components were recorded for each house. The decade of construction is recorded, based on QVNZ data..

Some component types have not changed greatly, e.g. timber framing is by far the major structural system in housing through the years, with the main change being from native to radiata timbers, and the introduction of dwangs.

Flooring types have changed from predominately strip timber suspended floors, to concrete slab and particleboard floors. Wall cladding types have also changed from predominately timber weatherboard, to brick and more recently a variety of new claddings including EIFS and fibre cement sheet. Linings types have also changed slightly, as shown later.

8.2.1 Exterior Wall Cladding

Table 12 and Figure 11 show exterior wall cladding types over the last 10 decades and last ten years in more detail than provided earlier. The summary of trends in the main cladding types are:

1. Timber/plywood: Has increased in share over the last 10 years, but has decreased significantly over the last few decades. This is mainly due to the increase of Clay brick houses from 1930's onwards.

2. Polystyrene (i.e. EIFS): Has decreased in share over the last 10 years (especially the last 6 years). It was introduced as a cladding type in the 1990's.
3. Plastic PVC weatherboards make up around 1-2% of all NZ houses over the last 10 years. There was not much change over the last 10 years. It was introduced as a cladding type in the 1980's.
4. Fibre Cement sheet has decreased over the last 10 years. It was introduced in the 1950's. Fibre Cement weatherboard/plank has increased over the last 10 years. It was introduced from the 1960's.
5. Clay brick cladding share has been increasing every decade especially from 1930 onwards.
6. Metal/Steel houses make up around 1-3% of all NZ houses over the last 10 years. There has been not much change over the last 10 years.
7. Stucco solid plaster has been around from early years, it increased in the 1930s and 40's, then declined until the 1990's with the "monolithic" fashion.
8. Concrete block/brick has only ever been a very small part of housing, apart from basements.
9. "Other" category is mainly Render (Plaster over brick), Stone, Tilt slab/panel.

Table 12 Wall Claddings Market Share of Stand-alone houses

Wall Claddings Market Share from BRANZ HCS survey										
Decade beginning:	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000 (2)
Timber/plywood cladding	82.2	82.7	78.6	51.0	55.8	42.8	33.4	22.9	24.4	10.8
Polystyrene EIFS	0.7	0.0	0.0	0.0	0.8	0.0	1.1	0.5	4.8	12.0
uPVC weatherboards (Plastic)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.7	1.3
Fibre cement sheet	5.2	3.9	2.5	5.4	5.5	11.9	14.2	15.8	11.2	8.4
Fibre cement weatherboard/plank	1.3	0.0	1.9	5.0	1.7	1.5	8.8	17.3	7.9	7.1
Clay Brick	0.4	2.7	5.1	15.1	17.4	23.4	20.8	28.9	33.5	41.2
Metal	0.8	0.0	0.0	0.0	0.3	0.3	0.0	0.0	1.9	2.1
Solid plaster	8.0	5.1	6.4	18.2	5.1	1.3	0.5	1.7	6.3	4.0
Concrete block	0.0	1.2	0.0	0.2	0.4	3.5	7.5	1.1	1.2	4.4
Concrete brick	0.0	0.2	0.0	0.0	3.2	11.8	9.5	6.5	3.1	0.8
Other (1)	1.4	4.2	5.4	5.2	9.7	3.5	4.2	4.6	3.1	7.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Wall Claddings Market Share from BRANZ New Dwellings materials survey										
	Year 1999	Year 2000	Year 2001	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008
Timber/plywood cladding	8.2	8.8	7.8	7.1	9.0	13.1	12.5	8.5	16.5	14.4
Polystyrene EIFS	12.6	15.2	17.0	17.2	11.5	12.0	8.8	10.4	7.1	8.5
uPVC weatherboards (Plastic)	1.0	1.1	0.9	1.3	1.6	1.2	1.2	1.4	1.6	1.7
Fibre cement sheet	15.8	18.5	15.5	16.1	6.8	3.0	3.1	4.1	4.7	3.3
Fibre cement weatherboard/plank	6.3	2.5	2.9	4.2	5.6	5.4	7.4	10.6	11.4	13.8
Clay Brick	42.2	38.7	38.6	40.0	43.9	43.2	42.7	47.4	37.7	38.7
Metal	0.5	0.8	2.3	1.5	3.2	2.9	3.1	1.0	1.9	2.2
Solid plaster	8.3	6.7	4.8	3.8	4.5	4.4	3.7	3.3	2.6	2.4
Concrete block	1.4	3.6	6.2	3.7	2.0	3.7	6.9	3.6	4.8	4.8
Concrete brick	0.6	1.5	0.9	0.9	0.4	0.8	2.0	0.5	0.3	0.2
Other (1)	3.1	2.7	3.0	4.4	11.4	10.3	8.7	9.2	11.5	10.0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

(1) Other is mainly Render, Stone, Tilt slab, AAC block/panel
(2) BRANZ materials survey

Note: Wall Cladding market shares for the last decade are from the BRANZ Materials Survey (Page 2005).

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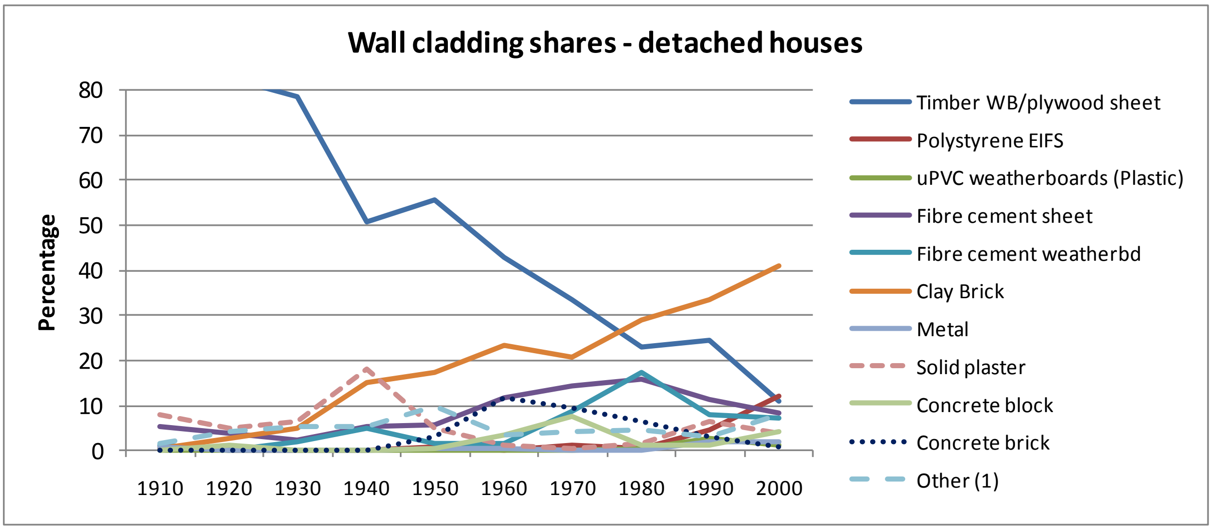

Figure 11 Wall Claddings Market Share by decade of Stand-alone houses

8.2.2 Flooring/Foundations

Figure 12 and Table 13 below shows the flooring types since 1910. Timber floors/foundations have overall decreased in housing numbers over the decades as concrete slab has increased since 1960. Tongue and groove has been obsolete since the introduction of particleboard and the latter is the most common timber flooring type. Concrete is a more fire-safe material than wood.

Note: The tables include later additions to early houses; so for example, there is a quite high concrete slab percentage for pre-1960s houses even though concrete slabs did not appear in the residential market until the 1960's.

Table 13 Flooring Market Share of Stand-alone houses

Flooring Market Share from BRANZ HCS survey										
decade beginning:	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Tongue & groove	83.3	82.7	81.1	79.8	75.8	65.5	18.0	4.4	15.5	unknown
Particleboard	5.6	9.3	10.1	10.2	10.8	10.0	33.5	35.5	13.4	14.7
Plywood	0.0	0.4	0.6	0.0	0.2	0.0	0.1	0.0	0.0	2.3
Strip timber	2.0	0.2	0.0	0.2	0.4	0.0	1.0	0.7	0.0	0.9
Concrete slab	9.1	7.4	8.2	9.7	12.8	24.6	47.4	59.4	71.1	82.1
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Flooring Market Share from BRANZ New Dwellings materials survey										
Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Particleboard	18.6	18.6	15.7	15.1	14.6	12.6	12.4	13.2	13.3	18.0
Plywood	0.5	0.6	0.9	1.1	2.0	2.8	2.6	3.6	3.2	3.9
Strip timber	1.8	1.6	1.2	0.9	1.2	0.9	0.3	0.6	0.5	0.4
Concrete slab	79.1	79.2	82.2	82.9	82.2	83.6	84.6	82.7	83.0	77.7
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
(1) Other is mainly Strip timber										
(2) BRANZ materials survey										

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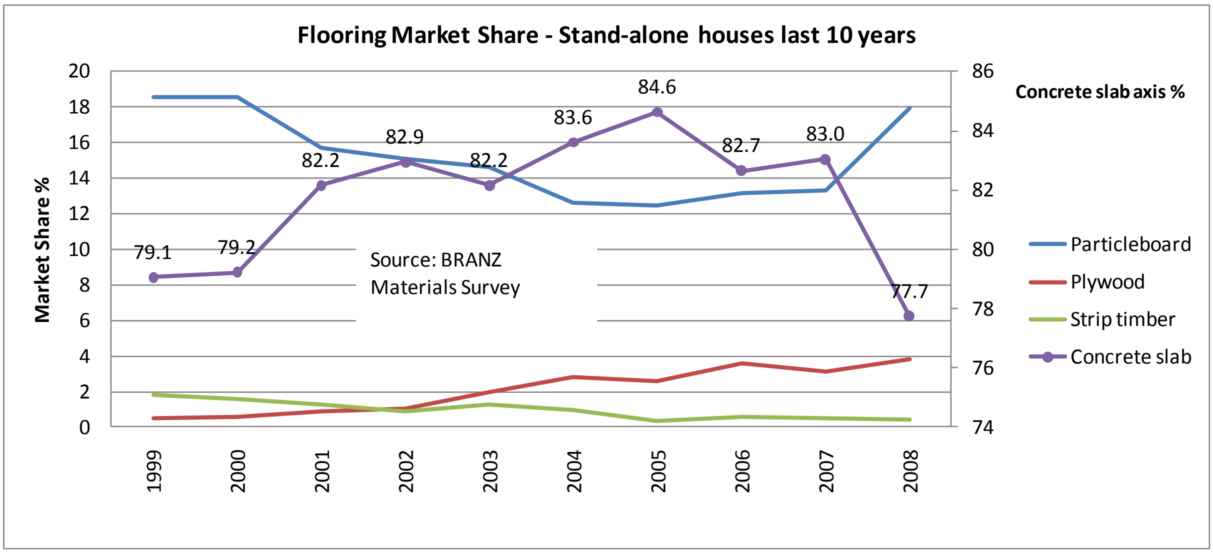


Figure 12 Flooring Market Share over the last ten years of Stand-alone houses

8.2.3 Wall Framing

Table 14 and Figure 13 below show the wall framing market share of stand-alone houses over the last 10 years. The most notable trend is radiata framing losing share to all other framing types (especially over the last 5 years), mostly to douglas fir. Steel and concrete block and concrete panels have both risen, but are still small in size.

Table 14 Wall Framing Market Share of Stand-alone houses

Wall Framing Market Share from BRANZ New Dwellings materials survey										
Calendar year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Radiata	95.5	98.5	92.6	89.8	96.3	88.1	85.6	82.0	79.2	80.6
Steel	0.1	0.2	0.2	0.3	0.1	1.1	1.5	1.0	3.3	1.3
Douglas Fir	1.4	0.9	3.2	4.2	2.2	5.2	7.7	10.9	8.5	8.1
Concrete	1.9	0.3	1.9	3.9	0.7	3.9	2.8	3.5	7.4	6.5
Other (1)	1.1	0.1	2.2	1.7	0.6	1.6	2.4	2.5	1.6	3.4
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

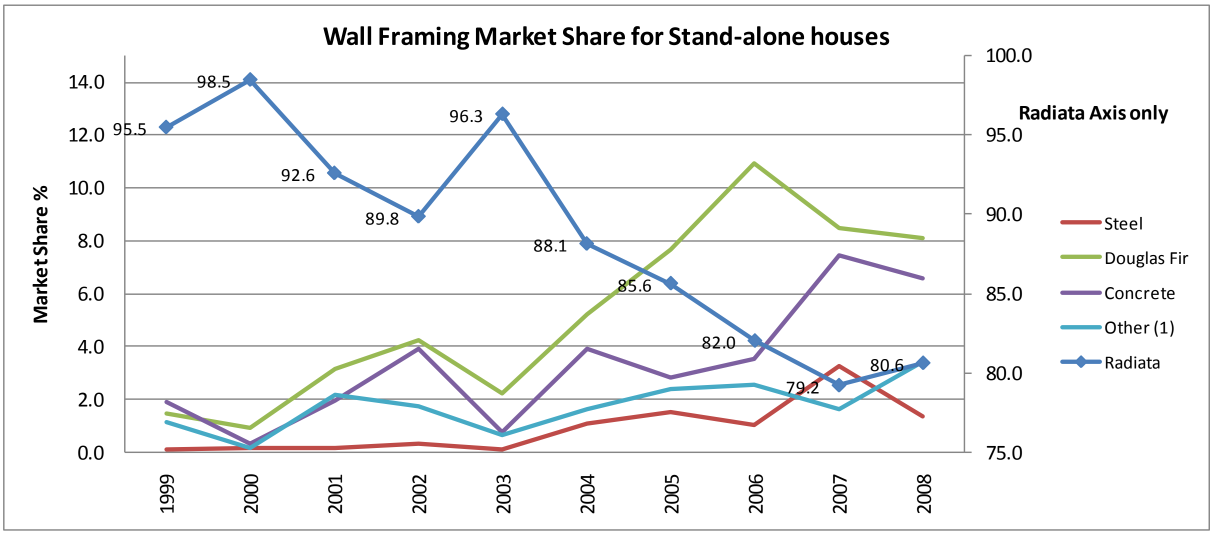
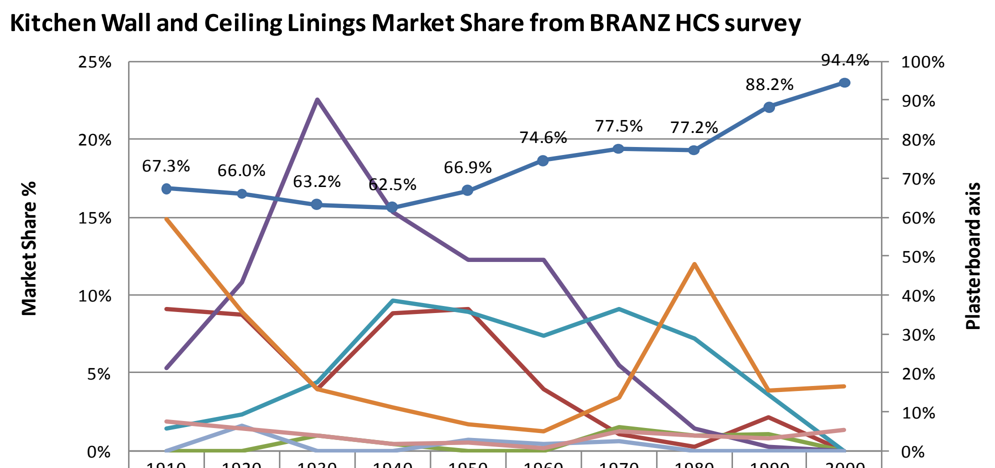


Figure 13 Wall Framing Market Share of Stand-alone houses

8.2.4 Internal Linings in Kitchens

Figure 14 below shows kitchen wall and ceiling internal linings in stand-alone houses over the decades. This segment is relevant because about 23% of fires originate in the kitchen (NZFS SMS database, July 2000 to March 2009). Plasterboard over the decades has steadily risen, with almost all houses in the 2000s made up of plasterboard. Timber linings (hardboard, particleboard, softboard, timber boarding) overall have decreased with plasterboard becoming more popular.



	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Hardboard	9.1%	8.7%	3.9%	8.9%	9.1%	4.0%	1.1%	0.2%	2.2%	0.0%
Particleboard/MDF	0.0%	0.0%	1.0%	0.4%	0.0%	0.0%	1.6%	1.0%	1.1%	0.0%
Fibrous plaster/lathe & plaster	5.3%	10.8%	22.5%	15.3%	12.2%	12.3%	5.5%	1.4%	0.3%	0.0%
Softboard	1.4%	2.4%	4.4%	9.7%	8.9%	7.4%	9.1%	7.2%	3.6%	0.0%
Timber boarding	14.9%	9.0%	3.9%	2.8%	1.7%	1.2%	3.4%	12.0%	3.8%	4.2%
Factory Finished panel	0.0%	1.7%	0.0%	0.0%	0.7%	0.4%	0.6%	0.0%	0.0%	0.0%
Other	1.9%	1.4%	1.0%	0.4%	0.6%	0.1%	1.3%	1.0%	0.8%	1.4%
Plasterboard	67.3%	66.0%	63.2%	62.5%	66.9%	74.6%	77.5%	77.2%	88.2%	94.4%

Figure 14 Wall and Ceiling Internal Kitchen Linings of stand-alone houses

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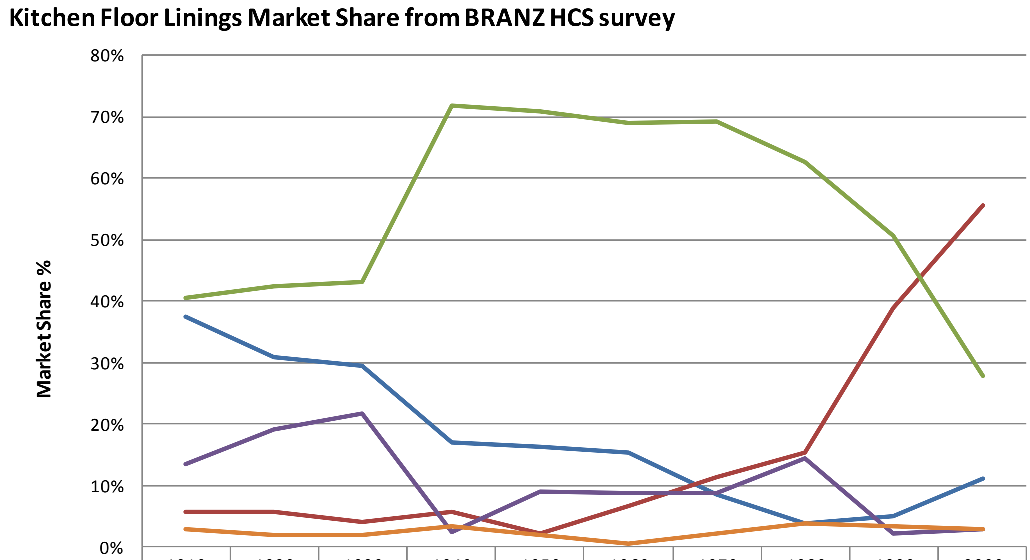
Figure 15 below shows kitchen floor linings in stand-alone houses over the decades. Vinyl floors over the last 3 decades have become less popular, in comparison, ceramic/slate/marble tiles have increased significantly. Uncovered strip timber and particleboard flooring has decreased over the years.

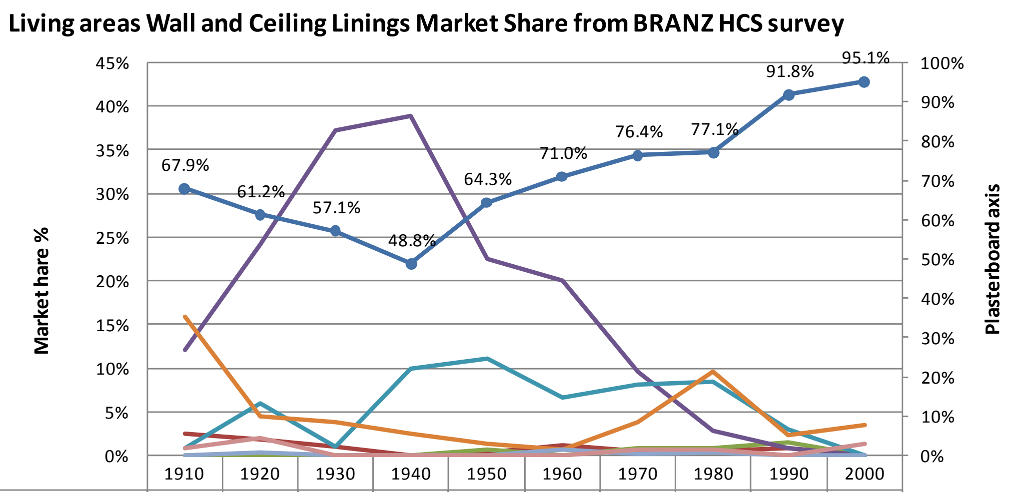


	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Timber	37.5%	31.0%	29.4%	16.9%	16.3%	15.3%	8.5%	3.8%	5.0%	11.1%
Ceramic, slate, marble Tiles	5.8%	5.7%	3.9%	5.6%	2.2%	6.6%	11.3%	15.4%	38.9%	55.6%
Vinyl	40.4%	42.4%	43.1%	71.8%	70.7%	68.9%	69.2%	62.5%	50.6%	27.8%
Cork Tiles	13.5%	19.0%	21.6%	2.4%	8.9%	8.7%	8.8%	14.4%	2.2%	2.8%
Other	2.9%	1.9%	2.0%	3.2%	1.9%	0.5%	2.2%	3.8%	3.3%	2.8%

Figure 15 Floor Linings of stand-alone houses

8.2.5 Internal Linings in Living areas and bedrooms

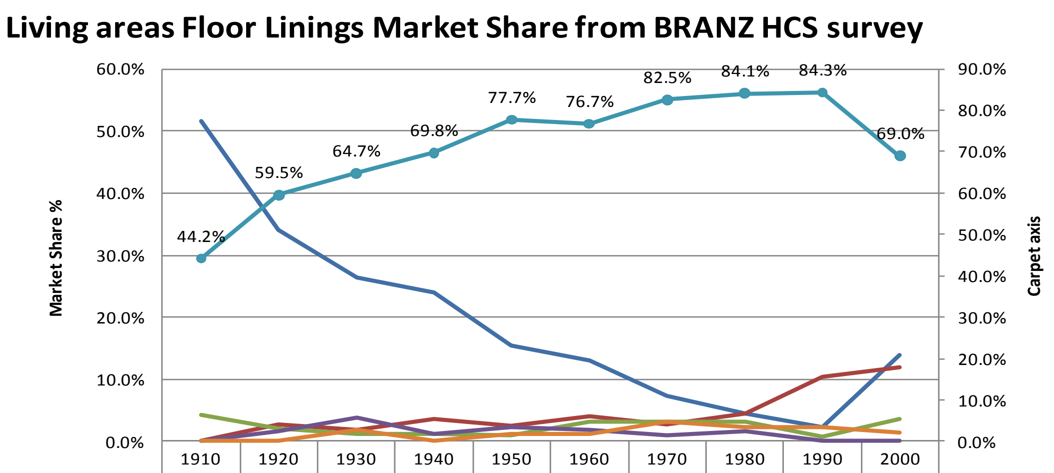
Figure 16 below shows living areas (lounge, dining, family rooms) and bedrooms wall and ceiling internal linings in stand-alone houses over the decades. About 37% of fires originate in these areas of the house (NZFS FIRMS database, July 2000 to March 2009). Plasterboard over the decades has steadily risen, with almost all houses from 1990s onwards made up of plasterboard. Timber linings (hardboard, particleboard, softboard, timber boarding) overall have decreased (especially over the last 20-30 years) with plasterboard becoming more popular.



	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Hardboard	2.5%	1.9%	1.0%	0.0%	0.2%	1.2%	0.5%	0.5%	0.7%	0.0%
Particleboard/MDF	0.0%	0.0%	0.0%	0.0%	0.6%	0.0%	0.8%	0.8%	1.5%	0.0%
Fibrous plaster/lathe & plaster	12.1%	24.1%	37.2%	38.9%	22.4%	19.9%	9.6%	2.7%	0.7%	0.0%
Softboard	0.8%	6.0%	1.0%	9.9%	11.0%	6.5%	8.1%	8.5%	3.0%	0.0%
Timber boarding	15.8%	4.4%	3.8%	2.5%	1.3%	0.7%	3.8%	9.5%	2.2%	3.5%
Factory Finished panel	0.0%	0.3%	0.0%	0.0%	0.0%	0.7%	0.2%	0.3%	0.0%	0.0%
Other	0.8%	2.0%	0.0%	0.0%	0.0%	0.0%	0.6%	0.7%	0.0%	1.4%
Plasterboard	67.9%	61.2%	57.1%	48.8%	64.3%	71.0%	76.4%	77.1%	91.8%	95.1%

Figure 16 Wall and Ceiling Internal Linings of stand-alone houses

Figure 17 shows floor linings of living areas and bedrooms over the decades. It shows a decreasing trend in timber floor linings and carpets increasing the covering of floors. Ceramic/slate/marble tiles have become more popular over the last 20 years.

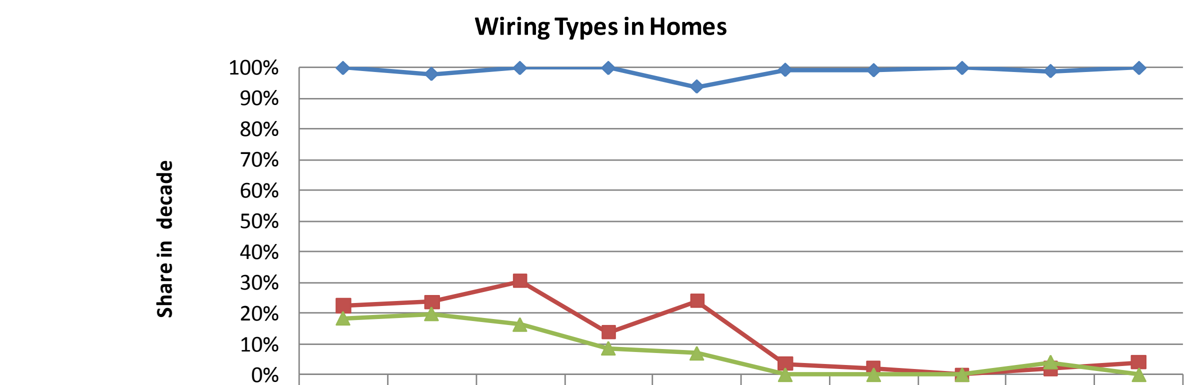


	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Timber	51.7%	34.0%	26.3%	24.1%	15.4%	13.0%	7.3%	4.4%	2.2%	13.9%
Ceramic, slate, marble Tiles	0.0%	2.7%	1.9%	3.7%	2.5%	4.1%	2.8%	4.4%	10.4%	12.0%
Vinyl	4.2%	2.0%	1.3%	1.2%	1.0%	3.1%	3.2%	3.1%	0.7%	3.7%
Cork Tiles	0.0%	1.7%	3.8%	1.2%	2.2%	1.8%	1.0%	1.6%	0.0%	0.0%
Other	0.0%	0.0%	1.9%	0.0%	1.2%	1.2%	3.2%	2.3%	2.2%	1.4%
Carpet	44.2%	59.5%	64.7%	69.8%	77.7%	76.7%	82.5%	84.1%	84.3%	69.0%

Figure 17 Flooring in living areas of stand-alone houses

8.2.6 Electrical Wiring inside the roof space

An earlier chart is reproduced in Figure 18 with the percentage below the chart. Most houses have tough plastic sheath wiring. .Rubber wiring types (Tough rubber sheath and Vulcanized Indian rubber) burn more readily than tough plastic sheath wiring and the rubber types deteriorate, becoming brittle with age and posing a fire risk. A downward trend shows tough rubber and vulcanized Indian rubber becoming almost obsolete in the roof space. Over the last 40-50 years, there are very few houses which have rubber type wiring (less than 5% of all houses).



	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
Tough Rubber Sheath	22.4%	23.8%	30.6%	13.8%	24.0%	3.6%	2.2%	0.0%	2.1%	4.0%
Vulcanised Indian Rubber	18.4%	19.8%	16.3%	8.6%	7.0%	0.0%	0.0%	0.0%	4.1%	0.0%
Tough Plastic Sheath	100.0%	98.0%	100.0%	100.0%	93.8%	99.4%	99.3%	100.0%	99.0%	100.0%

Figure 18 Wiring material types in homes over the decades

This chart shows the percentage of houses with the specified wiring type. The percentages often add to more than 100% because some houses, particularly older houses, have a mixture of wiring types, due to replacement of existing wiring and/or modern wiring types in later additions.

8.3 Fire severity by origin and material types

Figure 19 to Figure 21 show the trends in severity of fires by room or origin from the SMS. The top lines in each chart are for fires that have not caused extensive damage, and the percentage of these fires moves upward over time. Conversely the bottom lines are for fires where little of the house is saved and these, as a percentage of all fires move downward. So the trend over the years is for less damaging firings, though after 1991 the improving trend appears to have levelled off and deteriorated slightly.

Similar data is in Table 15 where these fires are expressed as the number per year per 10,000 houses, for each age group. When the incidence for these three types of fire are summed and compared to the total fire incidence in Table 1, the three fire origins account for over half of all fires.

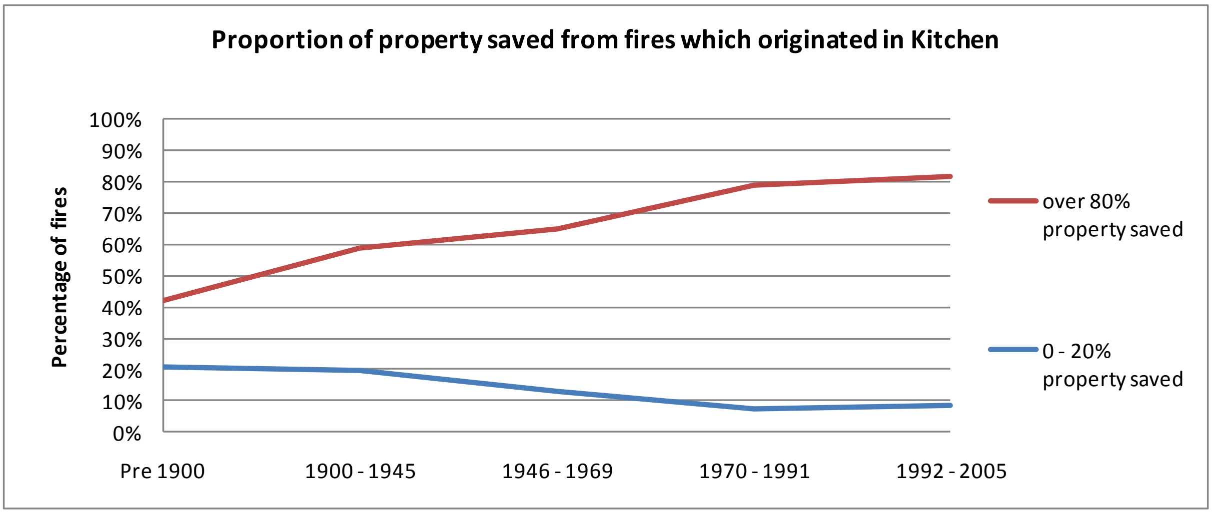


Figure 19 Property saved % for kitchen fires

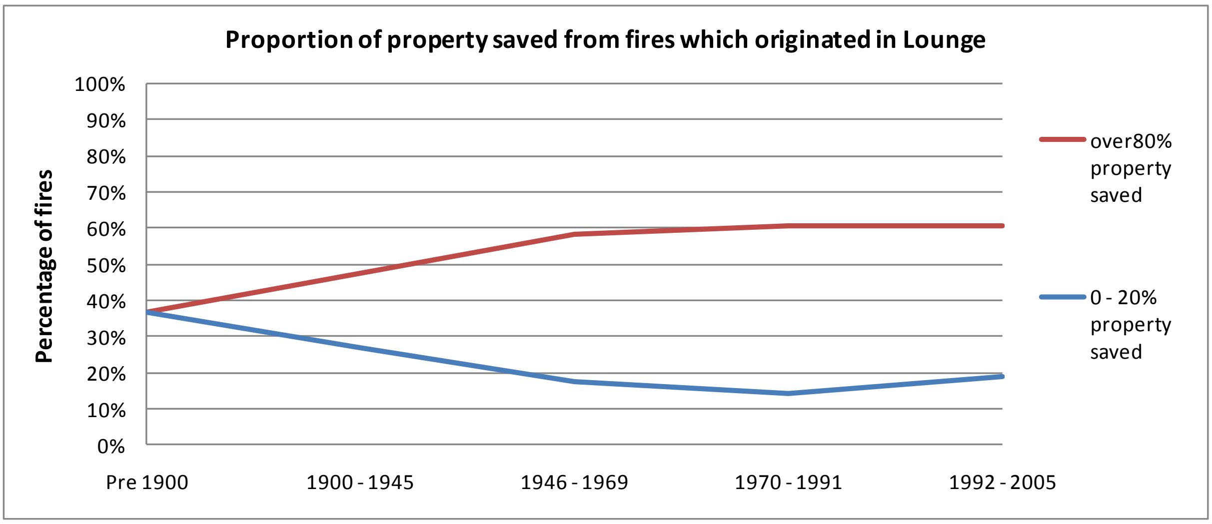


Figure 20 Property saved % for lounge fires

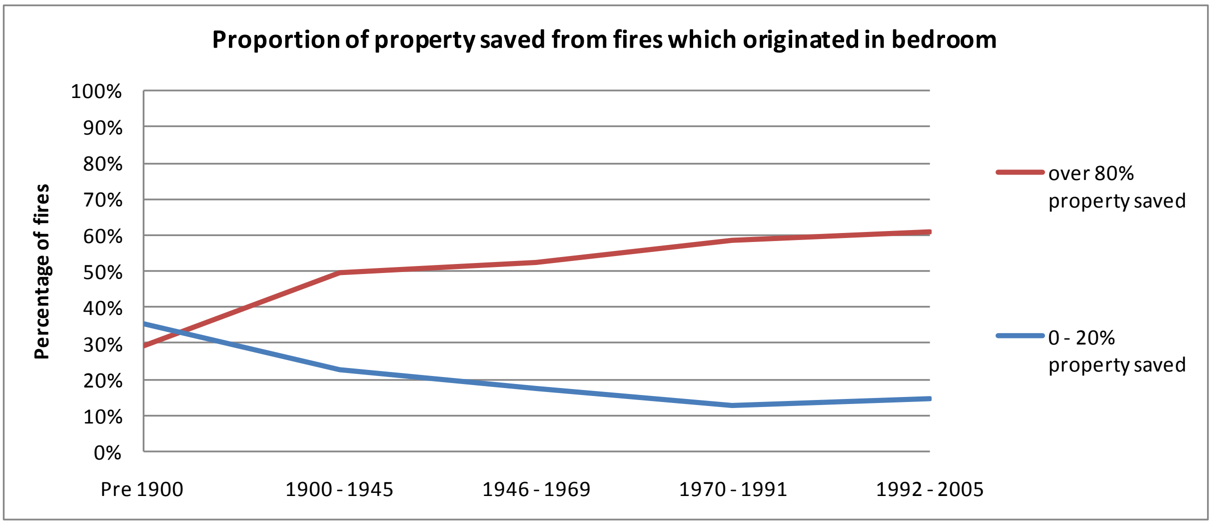
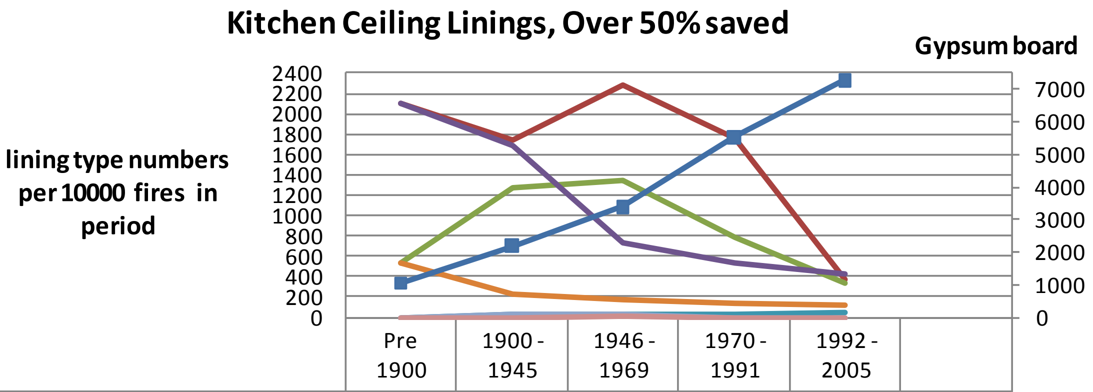


Figure 21 Property saved % for bedroom fires

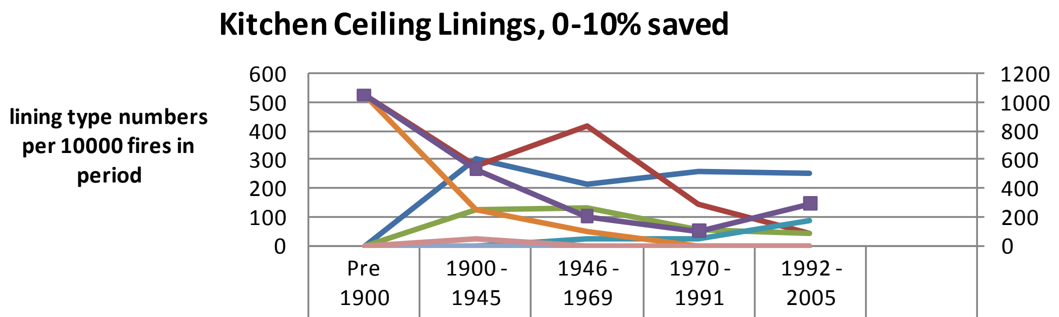
Table 15 Fire severity by room of origin by age group

Kitchen originated fires					
	Percent of property saved				Fires per
	0 - 20%	21% to 80%	over 80%	All fires from origin	10000 houses
Year built	Number of fires				per year
Pre 1900	4	7	8	19	3.6
1900 - 1945	79	87	236	402	1.8
1946 - 1969	130	227	656	1013	2.6
1970 - 1991	65	124	716	905	2.8
1992 - 2005	20	24	197	241	1.0
2006 onwards	0	0	3	3	0.1
Lounge originated fires					Fires per
	0 - 20%	21% to 80%	over 80%	All fires from origin	10000 houses
Year built	Number of fires				per year
Pre 1900	11	8	11	30	5.8
1900 - 1945	123	116	217	456	2.1
1946 - 1969	157	214	520	891	2.3
1970 - 1991	92	163	390	645	2.0
1992 - 2005	30	32	96	158	0.6
2006 onwards	0	0	8	8	0.1
Bedroom originated fires					Fires per
	0 - 20%	21% to 80%	over 80%	All fires from origin	10000 houses
Year built	Number of fires				per year
Pre 1900	6	6	5	17	3.3
1900 - 1945	67	82	147	296	1.3
1946 - 1969	122	216	370	708	1.8
1970 - 1991	92	205	417	714	2.2
1992 - 2005	28	46	116	190	0.8
2006 onwards	0	1	3	4	0.1
SMS database July 2000 to April 2009.					

Figure 22 to Figure 24 show lining types per 10,000 fires from the SMS database. Some materials are on the secondary axis. It contains the raw data for the derivation of Table 15, and the numbers are the totals for the complete period July 2000 to April 2009.



	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Pinex	2105	1735	2277	1759	377
Fibrous plaster	526	1276	1336	780	335
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	2105	1684	729	535	418
No lining present	0	26	20	22	42
Combination of materials	526	230	172	134	126
Metal: Aluminium, Steel, Metallic alloy	0	26	20	0	0
Plastic	0	0	10	0	0
Gypsum board (e.g. Gib board, Elephant board)	1053	2194	3401	5535	7280



	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Gypsum board (e.g. Gib board, Elephant board)	0	306	213	256	251
Pinex	526	281	415	145	42
Fibrous plaster	0	128	132	56	42
No lining present	0	0	20	22	84
Combination of materials	526	128	51	0	0
Metal: Aluminium, Steel, Metallic alloy	0	0	0	0	0
Plastic	0	26	0	0	0
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	1053	536	202	100	293

Figure 22 Kitchen Ceiling Linings

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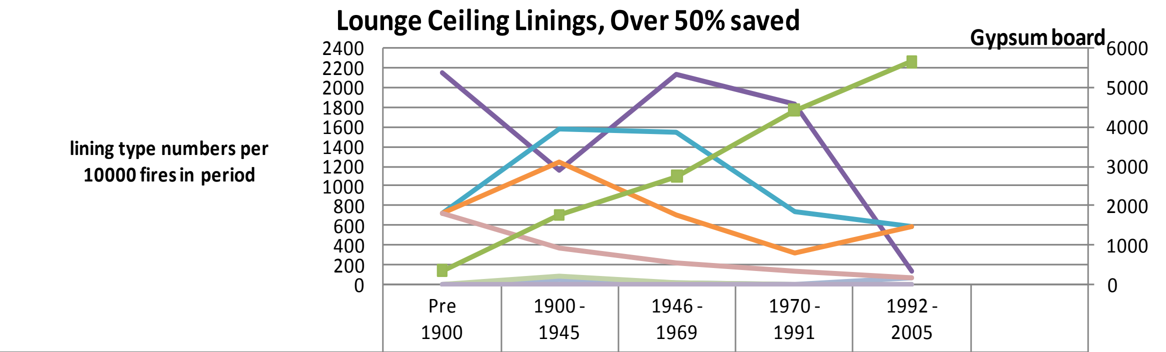
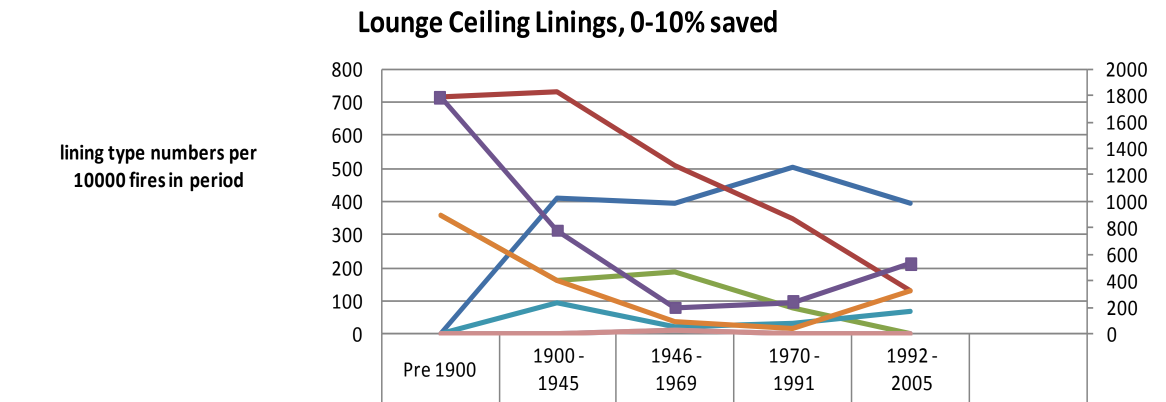
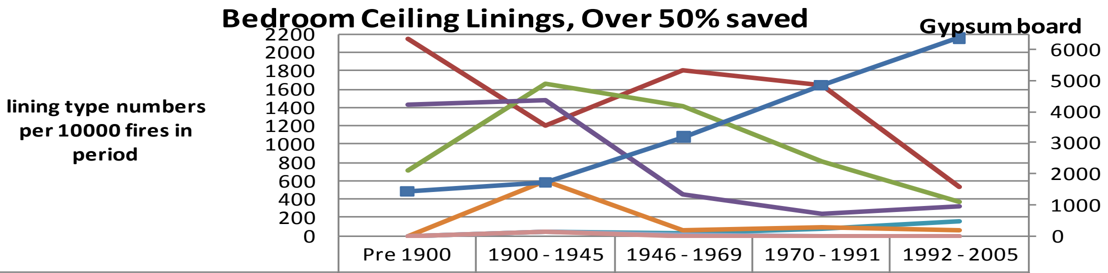


	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Pinex	2143	1167	2139	1833	132
Fibrous plaster	714	1579	1538	742	592
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	714	1236	705	316	592
No lining present	0	46	12	0	66
Combination of materials	714	366	220	126	66
Metal: Aluminium, Steel, Metallic alloy	0	92	12	0	0
Plastic	0	0	0	0	0
Gypsum board (e.g. Gib board, Elephant board)	357	1762	2740	4423	5658

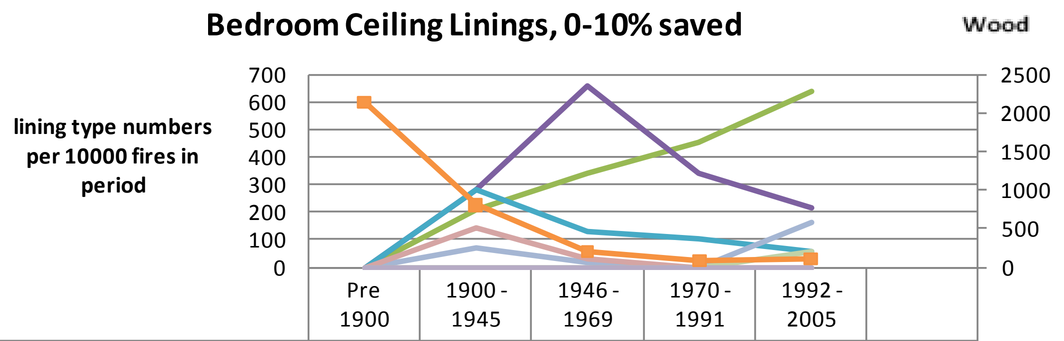


	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Gypsum board (e.g. Gib board, Elephant board)	0	412	393	506	395
Pinex	714	732	509	348	132
Fibrous plaster	357	160	185	79	0
No lining present	0	92	23	32	66
Combination of materials	357	160	35	16	132
Metal: Aluminium, Steel, Metallic alloy	0	0	12	0	0
Plastic	0	0	12	0	0
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	1786	778	197	237	526

Figure 23 Lounge Ceiling Linings



	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Pinex	2143	1197	1803	1641	532
Fibrous plaster	714	1655	1416	813	372
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	1429	1479	458	243	319
No lining present	0	35	29	71	160
Combination of materials	0	599	57	100	53
Metal: Aluminium, Steel, Metallic alloy	0	35	14	0	0
Plastic	0	35	0	0	0
Gypsum board (e.g. Gib board, Elephant board)	1429	1725	3176	4850	6383



	Pre 1900	1900 - 1945	1946 - 1969	1970 - 1991	1992 - 2005
Gypsum board (e.g. Gib board, Elephant board)	0	211	343	456	638
Pinex	0	282	658	342	213
Fibrous plaster	0	282	129	100	53
No lining present	0	70	14	0	160
Combination of materials	0	141	29	0	0
Metal: Aluminium, Steel, Metallic alloy	0	0	0	0	53
Plastic	0	0	0	0	0
Wood: T&G, Hardboard, Chipboard, Customwood, Plywood	2143	810	200	86	106

Figure 24 Bedroom Ceiling Linings