FIRE DESIGN AND TIMBER FRAMED BUILDINGS

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Summary

This paper provides:

- Brief overview NZBC requirements
- Product and System testing
- Fire Rated Systems and Solid timber members

NZBC Requirements for Fire Safety

The New Zealand Building Code (NZBC) deals with health and safety, and not property protection except when affects life safety or adjacent property. In other words, provided the safety of the building occupants is adequate, what happens to the building in a fire is left to the insurance industry and not considered requiring government control.

Fire safety design depends on:

- Building use and number/mobility of occupants
- Fire load or Fire Hazard Category (FHC)
- Building dimensions
- Proximity to a relevant property boundary

Usually fire safety design will incorporate a combination of active fire protection and passive fire protection systems.

Active fire protection measures include:

- Smoke detection
- Heat detection
- Sprinklers (required in most 'sleeping purpose groups' and all buildings over 25 m in height)
- Gas flood systems (replacing oxygen in case of a fire)
- Mechanical smoke extraction
- Stair pressurisation

Passive fire protection measures include:

- Building design features (number of exits, escape route dimensions, etc)
- Reaction to fire or surface finish properties
- Barriers with a Fire Resistance Rating (FRR)

Passive fire protection can be required to protect adjacent property or the health and life safety of the building occupants.

Adjacent property protection involves:

- The provision of boundary walls with a FRR where a building is located sufficiently close to a property boundary. Requirements were increased in 2001 by 30% to take account of the common form of framed and insulated construction in New Zealand. In terms of fire growth this means that heat is not readily soaked up by the construction elements and builds up quickly within the compartment
- Limiting permitted openings in the external walls, depending on distance to the boundary, building height, and FHC.
- Controlling surface finish properties including the rate of heat release of cladding materials, depending on distance to boundary, building height, Purpose Group and FHC

Life safety requirements aim to protect occupants during evacuation and the fire service during fire fighting and rescue. They include,

- Limitations on internal surface finishes (e.g. in exit ways)
- Fire-cell or F-ratings. These were reduced in 2001 to FRR 30 minutes or less in most cases which is out of step with most other developed countries were higher ratings are common

Furnace Testing and Building Fires

It is important to realise that a standard furnace test is usually repeatable but building fires are never the same. A furnace test on a wall is shown in Figure 1 and a building fire in Figure 2.

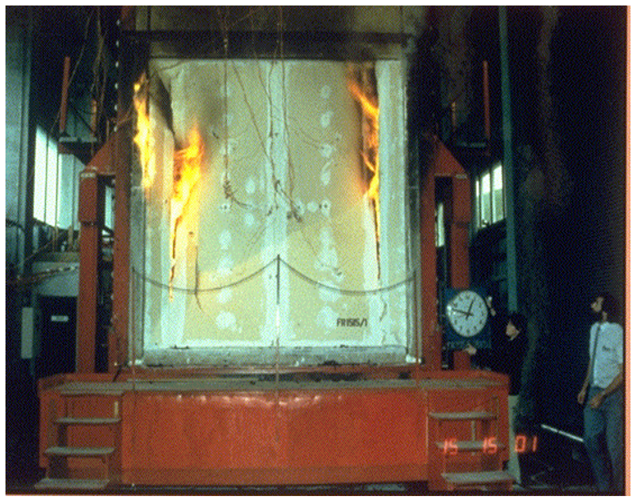

Figure 1: *Standard furnace test*

Figure 2: *Building fire*

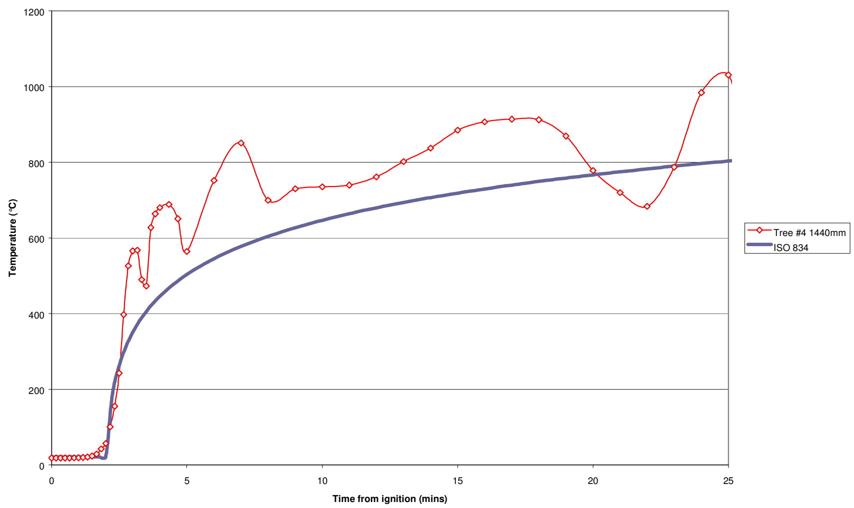

***Figure 3:** Standard furnace test temperatures compared with a compartment fire*

Figure 3 compares the standard ISO furnace time-temperature curve with the temperatures achieved in an actual compartment fire. It is important to remember that the furnace test fire is a comparative measure and temperatures are always the same. Building fires are never the same and generally hotter than the standard furnace fire. Minutes achieved in the furnace test must not be directly equated to actual minutes available for evacuation and fire service operations.

There are many reasons why furnace tests and building fires are different. A furnace test simulates a wood-crib fire in a concrete compartment whereas NZ buildings are commonly framed and insulated, and no restrictions apply to foam plastic furnishings. Building fires are often more severe than furnace tests although of shorter duration, depending on ventilation conditions and the amount of fuel available for burning. Fire rated barriers degrade when exposed to radiant heat energy. Radiant heat energy is proportional to the absolute temperature raised to the 4^{th} power (K^4). This means that a small increase in temperature equates to a large increase in radiant heat energy. In actual buildings, fire rated barriers can fail much earlier than indicated by the furnace test (FRR).

Timber Framing in Fire

Although timber framing is combustible, it can provide effective fire resistance as part of a fire rated assembly with fire resistant linings such as gypsum plasterboard. A main benefit of timber framing is that it remains relatively straight when exposed to fire, which minimises any stress on the wall linings. If the fasteners holding the linings to the frame are long enough to penetrate the developing char layer, then effective fire resistance is provided with timber framing. Figure 4 shows the performance of a timber-framed wall lined with gypsum plasterboard in an actual building fire. The wall separates an office block from a factory unit. Note the extensive damage to the structural steel frame on the factory side. As can be seen, the unexposed office side of the timber-framed wall survived the fire very well.

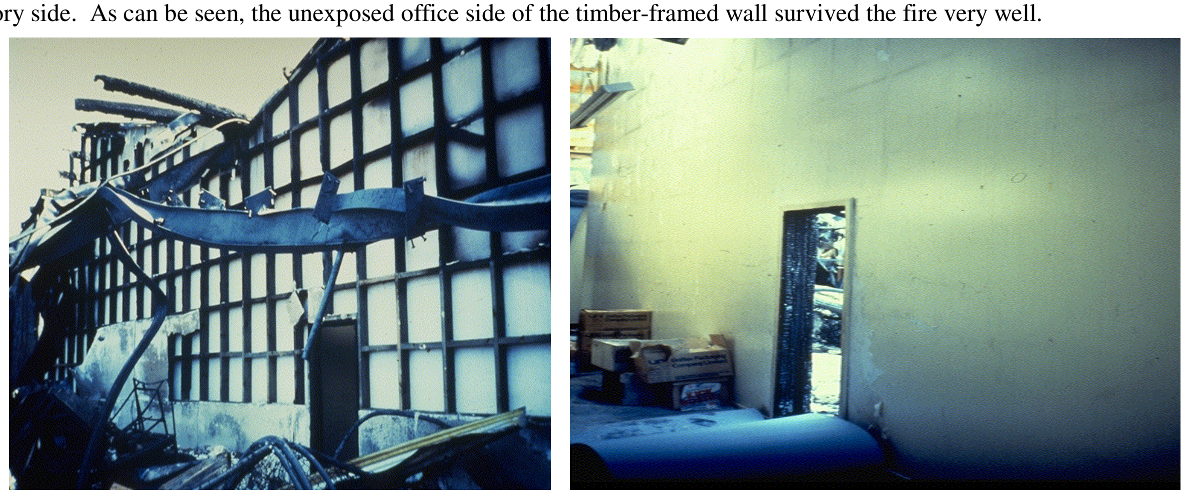

***Figure 4:** Timber framed partition lined with gypsum plasterboard after a building fire*

Fire Resistance Ratings

Fire resistance ratings are expressed as X/Y/Z, (e.g. 60/60/60) where:

X is the stability value in minutes
Y is the integrity value in minutes
Z is the insulation value in minutes

Stability refers to the collapse of load-bearing elements during a fire. Integrity refers to the time for penetration or hot gases. Insulation refers to transmission of heat and an unacceptable temperature rise exceeding 140 °C on the unexposed side of the fire rated system. A dash (-) indicates a nil rating. Examples are a load bearing plasterboard wall at 30/30/30, a non load-bearing wall with -/30/30, or fire rated glass with FRR of -/30/-.

A Fire Resistance Rating results when several components are correctly installed in a system. Careful attention to detail is required. GIB® technical literature provides all the detail required to construct a fire rated assembly. Do not substitute any component and stick closely to the specifications.

As regards the timber framing

- Check required framing dimensions
- Consult NZS 3604 for wall heights to 4.8 m
- Beyond this specific design is required
- Design guidelines are available for walls outside NZS 3604
- These guidelines ensure that the FRR is maintained (but are not a substitute for serviceability design)
- Number of layers and fastener size depends & thickness of board
- Check the correct fastener type, length and centres
- Fastener penetration into timber is particularly important. Using shorter fasteners could result in the sheet "letting go" prematurely due to timber charring
- Glue can not replace mechanical fasteners in GIB® Fire Rated systems

As regards gypsum plasterboard linings

- Ensure correct linings are used
- Ensure the correct fastener type and length
- Form sheet joints over framing
- Use full height sheets where possible
- If a sheet-end butt joint is unavoidable it must be formed over a timber nog
- Offset joints on each side and in double layered systems
- Taping and stopping is an integral part of the fire rated system

The same requirements apply to fire rated ceilings with the following special conditions,

- Flooring particle board sheet joints joints are supported by nogs
- Some composite joist systems have been tested or have BRANZ assessments (CHH Hyspan or Hybeam, Origin I-beam, Twinaplate)
- Others are available (e.g. nail plate truss joists), but do not simply assume they work

For solid timber columns and beams no less than 90 mm in any dimension, their FRR may be calculated from the timber char rate given in NZS 3603 Section 9. This specifies a char rate of 0.65 mm/minute. Check strength of residual cross section after a certain time of char, but remember, that this is a char rate for the standard ISO furnace test conditions and the building fire may be more severe resulting in increased char. Use this design method with care.