

# Properties for Fire Engineering Design in New Zealand and the IFC Building Product Model



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# Objectives

Background to fire engineering and its information needs

Compare the IFC 2x Model and the New Zealand Acceptable Solution for fire engineering design

Expansion of the IFC Model using Property Set Definitions

# Fire Engineering Design

The New Zealand Building Code is a performance-based code that includes the following fire safety requirements:

- Providing means of escape to occupants
- Preventing the spread of fire to neighbouring property
- Providing protection to fire service personnel during fire-fighting
- Limiting the effects of fire to the environment

These requirements can be addressed by considering issues such as:

- Exit route design
- Fire and smoke spread mechanisms
- Structural stability



*The building code can be met by following published acceptable design methods or considering alternative solutions using fire-specific design*

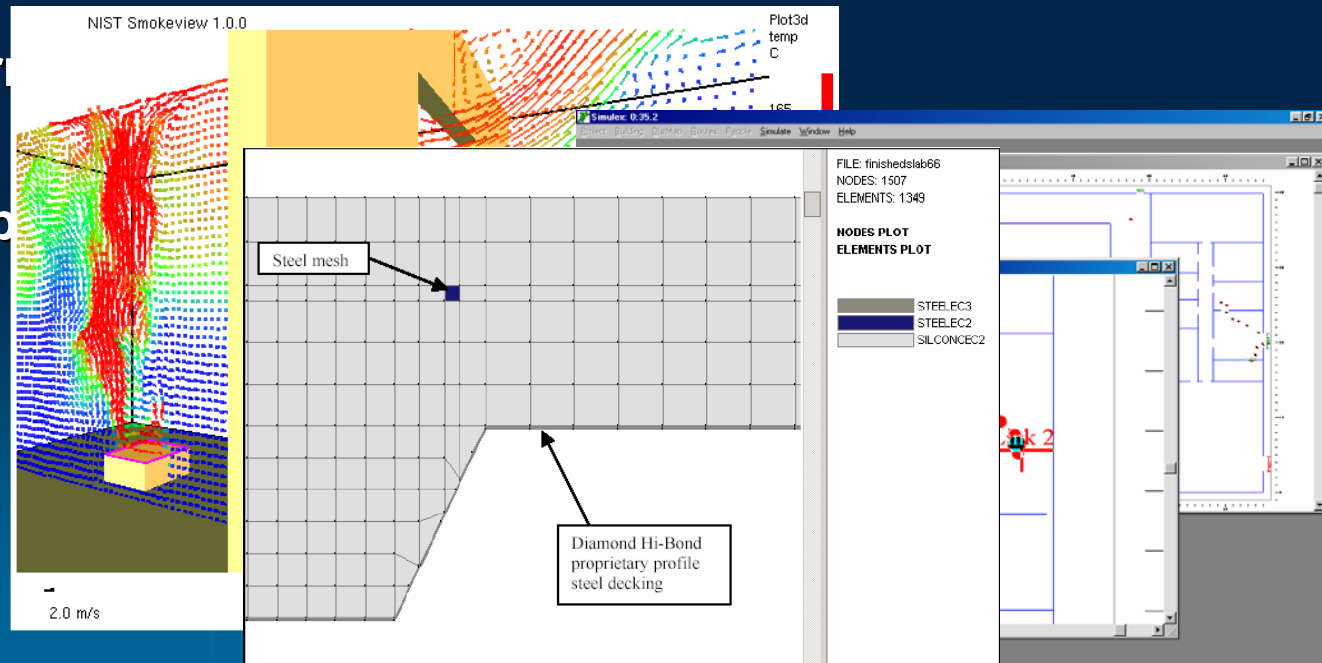
# Fire Engineering Design

In many cases computer models are used to assess alternative designs

- Fire & smoke spread

- Thermal

- People

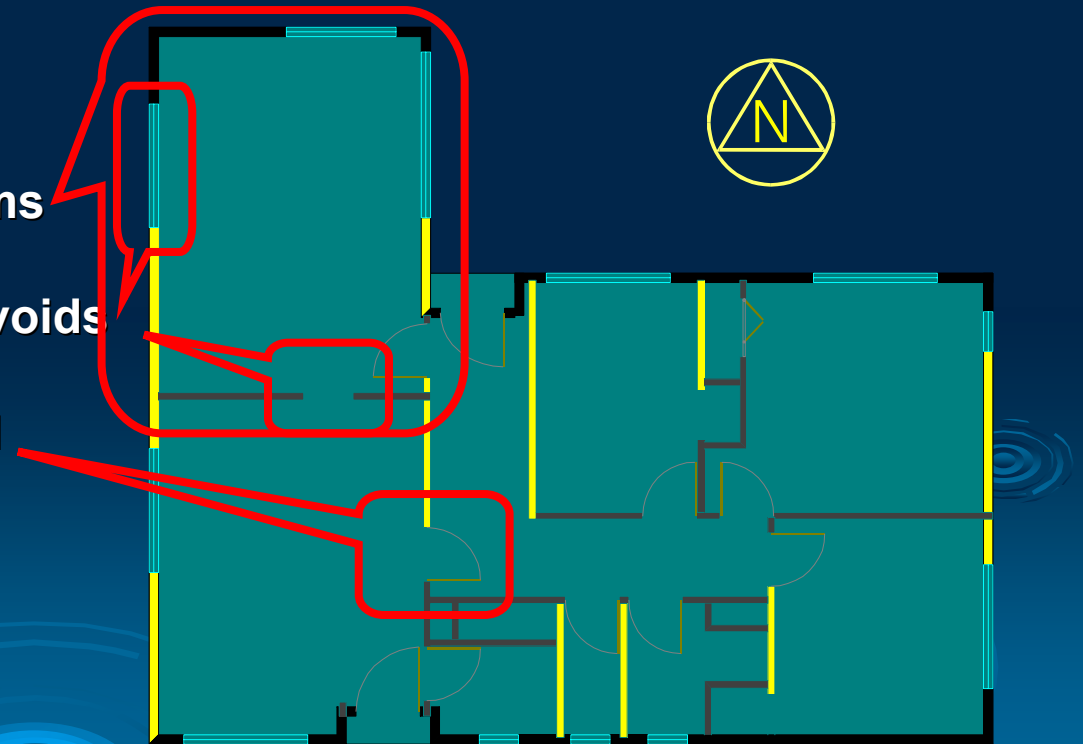


# Common Elements

There are many aspects of a building that are common to the fire engineering domain and other domains such as architecture, structural engineering and building services

Fire engineers need to have the basic geometry and topology of a building such as:

- **Size and shape of rooms**
- **Openings and hidden voids**
- **Exits from a space and where the exits leads**




# Common Elements

Fire Engineers may also require information about the site of the building and weather factors such as:

- **Temperature**
- **Wind velocity**
- **Humidity**

and the occupancy characteristics of the building:

- **Primary use of spaces**
  - **Number of people**
  - **Times when the building will be occupied**
  - **Who the building will be occupied by**
  - **Physical and mental state of the occupants**
- 

# Domain Specific Elements

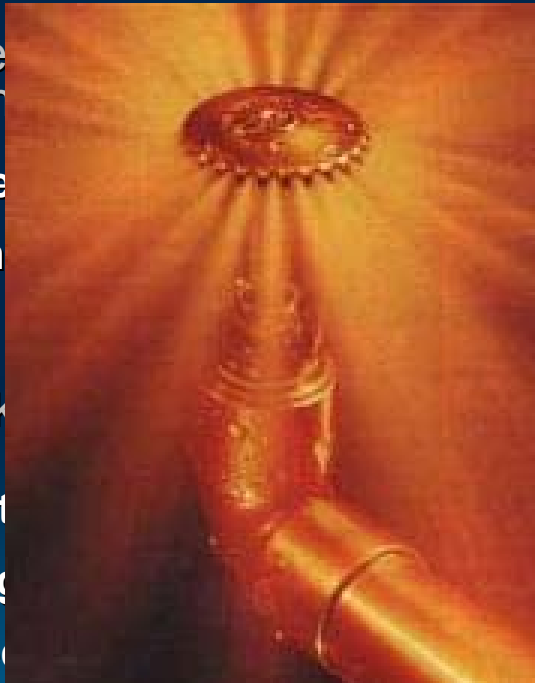
Fire engineers are involved in the specification and design of specific fire safety systems such as alarm, suppression and smoke management systems.

They need to consider the potential of fuels in the building

- **Content**
- **Arrangement**

Fuel packages

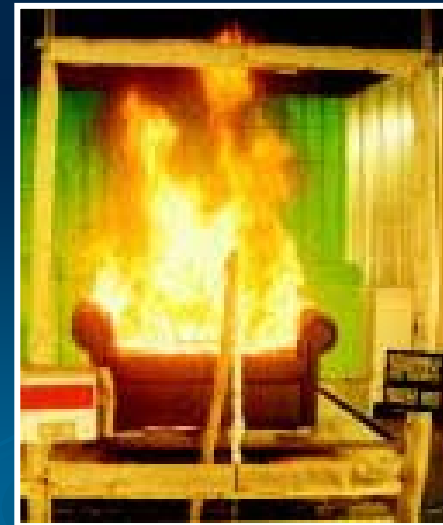
- **Furniture**
- **Fittings**
- **Storage**
- **Wall, floor and ceiling coverings**



that could occur through an assessment

**of total fuel load**

**ability of fuel packages**



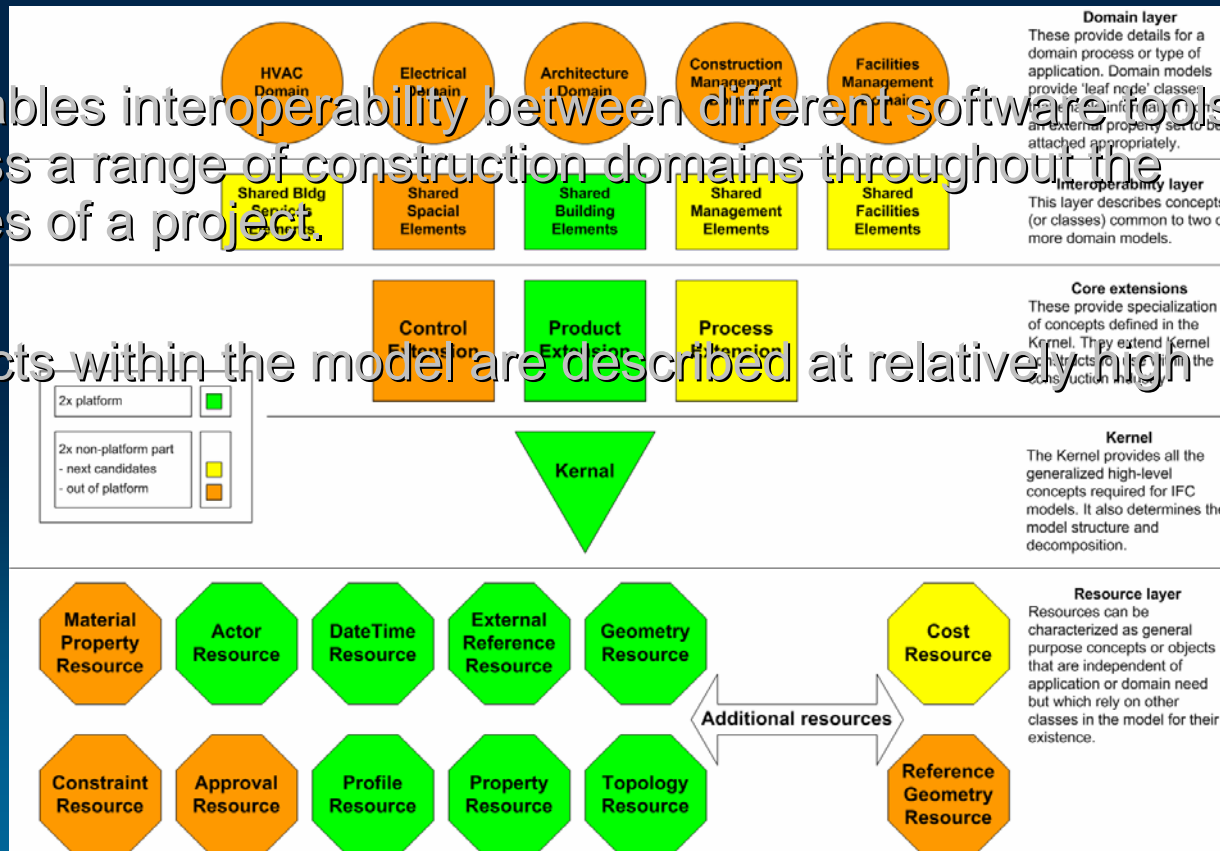
# IFC Building Product Model

## What is the IFC Building Product Model?

The IFC Product model is a general product model that provides an object-oriented description of many aspects of a building and related services.

It enables interoperability between different software tools across a range of construction domains throughout the stages of a project.

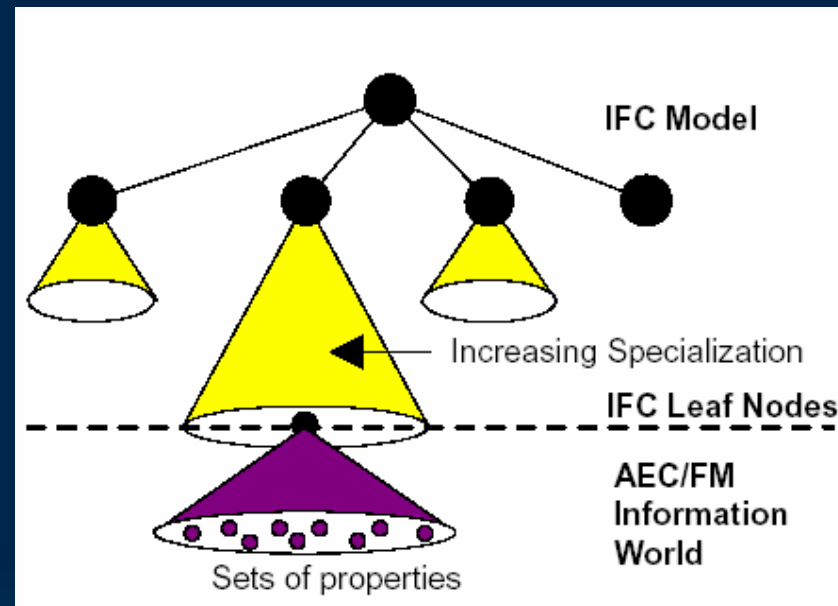
Objects within the model are described at relatively high level.





# IFC Building Product Model

## Limits of the IFC Model



Limits of the IFC Model from Liebich & Wix (2000).

The IFC Model allows additional property sets so that more detail can be accommodated in the model. Specialists within segments of the construction industry can carry out the task of defining property sets for IFC Model objects.

# Property Categories

## Three categories of building elements

Within the context of fire safety, the properties of building elements can be thought of belonging to three major groups:

- **Category 1**: The fundamental thermo-physical properties of a building element.
- **Category 2**: Fire specific properties that may have been obtained by measurement or some other means.
- **Category 3**: Properties that have been obtained for regulatory or standardisation purposes.

# Property Categories

## Category 1

The IFC model has the potential to allow fire engineers to automate compliance checking with published acceptable methods. It also allows fire engineers to extract the relevant building information to conduct alternative designs using fire modelling software.

Many of the Category 1 fundamental properties can already be found in IFC 2x, including

- **ifcEnergyMeasure**
- **ifcHeatFluxDensity**
- **ifcSpecificHeatCapacityMeasure**
- **ifcThermalConductivityMeasure**

***IFC 2x recognises the fact that buildings contain elements with properties specifically related to fire engineering – the majority of which are Category 3 properties...***

Property set definition and associated IFC class	Fire specific property name	Data type	Definition
Pset_DoorCommon (IfcDoor)	FireRating	IfcString	Fire rating of complete door assembly. Given according to the national fire safety classification.
Pset_Insulation (IfcDiscreteElement)	FlamabilityRating	IfcString	Insulation flammability rating.
Pset_CoveringCommon (IfcCovering)	FireRating	IfcString	Rating indicating the time duration before fire would penetrate this ceiling
Pset_RoofCommon (IfcRoof)	FireRating	IfcString	Time duration for fire resistance the roof assembly is rated.
Pset_SlabCommon (IfcSlab)	FireRating	IfcString	Fire rating of slab.
Pset_SpaceCommon (IfcSpace)	MainFireUse	IfcString	Main fire use for the space which is assigned from the Fire Use Classification.
	AncillaryFireUse	IfcString	Ancillary fire use for the space which is assigned from the Fire Use Classification.
	FireRiskFactor	IfcInteger	Fire Risk factor assigned to the space
	SprinklerProtection	IfcBoolean	Indication whether the space is sprinkler protected (true) or not (false).

# New Zealand Approved Documents

## C/AS1 and IFC 2x

The Approved Document Acceptable Solution C/AS1 is one of the methods a fire engineer can demonstrate a building complies with the performance criteria of the New Zealand Building Code.

C/AS1 is a set of design methods that address the fire safety requirements of buildings. C/AS1 is used by fire engineers for many simple, low-rise buildings in New Zealand.

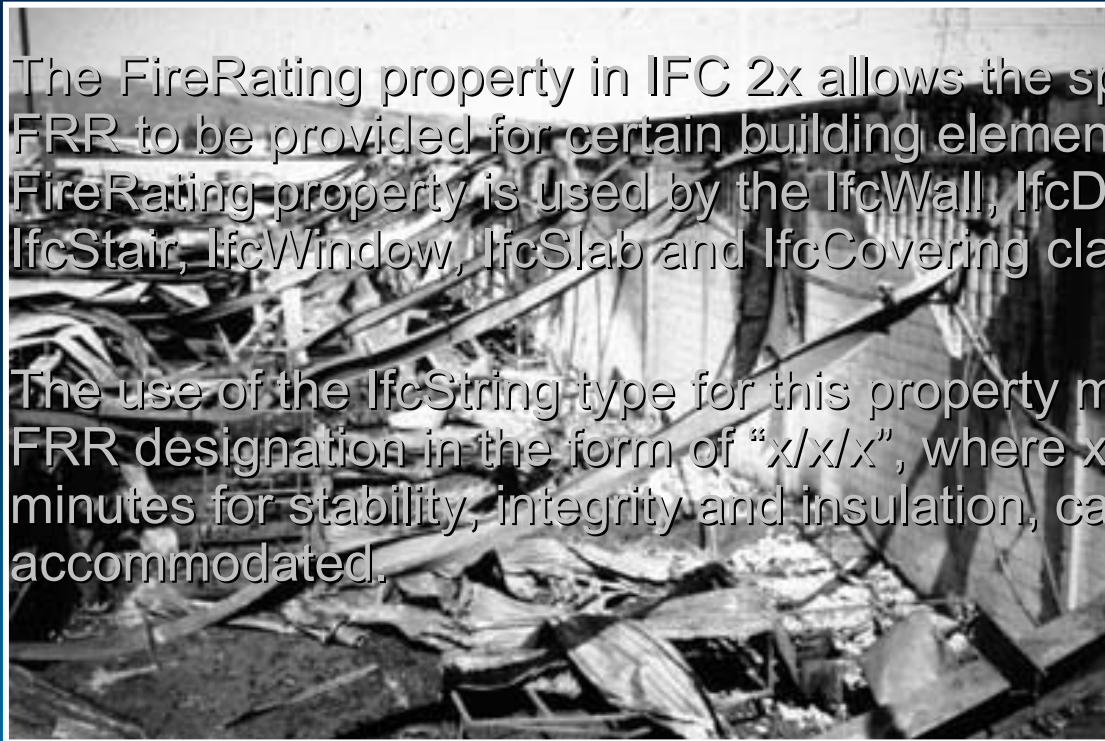
The majority of fire specific properties in IFC 2x belong to our Category 3 regulatory properties so how closely do these fire-related properties integrate with the regulatory requirements of C/AS1?

# C/AS1 - Fire resistance

In most buildings certain elements are provided with a fire resistance in order to prevent the spread of fire and smoke or avoid structural collapse during a significant fire. C/AS1 specifies fire resistance ratings (FRR) using three numbers indicating values for stability, integrity and insulation in minutes.

The FireRating property in IFC 2x allows the specification of the FRR to be provided for certain building elements. The FireRating property is used by the IfcWall, IfcDoor, IfcRoof, IfcStair, IfcWindow, IfcSlab and IfcCovering classes.

The use of the IfcString type for this property means that the FRR designation in the form of "x/x/x", where x are times in minutes for stability, integrity and insulation, can be accommodated.





# C/AS1 - Space utilisation

In order to assess the occupancy characteristics, C/AS1 categorises building spaces into purpose groups and fire hazard categories (FHC).

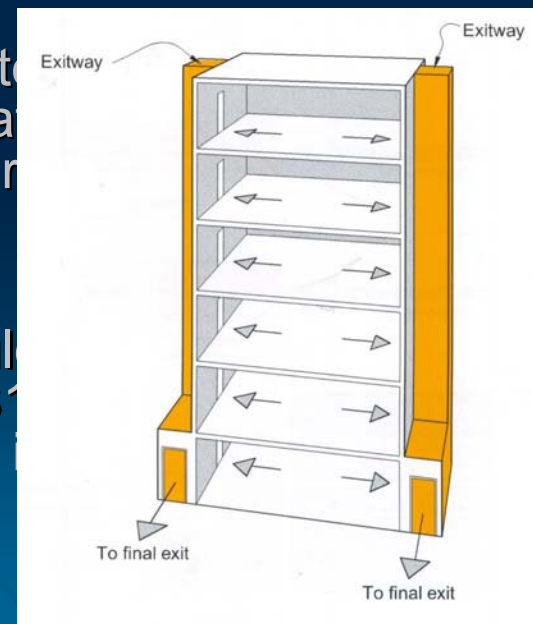
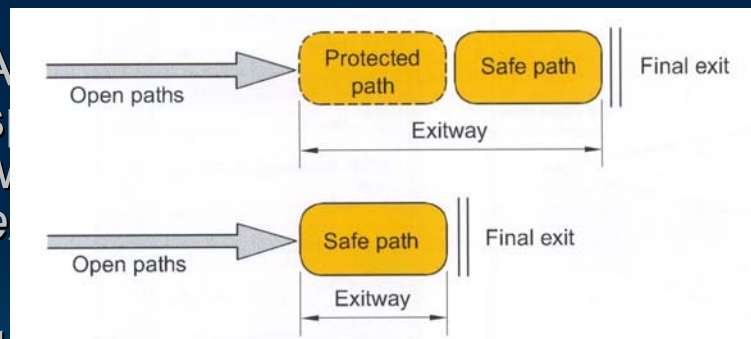
C/AS1 contains around 16 specific purpose groups subdivided into four major activity sets that identify the broad use of the space. Each purpose group also has an associated FHC designation that identifies the fuel characteristics in the space.

Purpose Group	Description of the intended use of the space	Some examples	Fire hazard category
<b>CROWD ACTIVITY</b>			
CA	Spaces where occupancy exceeds 100	Cinema, schools, colleges...	2
<b>SLEEPING ACTIVITY</b>			
SA	Spaces providing transient accommodation	Motels, hotels, hostels...	1
<b>WORKING BUSINESS OR STORAGE ACTIVITY</b>			
WB	Spaces used for working, business or storage - low fire load	Manufacturing, processing or storage of materials having a slow heat release rate	1
<b>INTERMITTENT ACTIVITY</b>			
IA	Spaces for intermittent occupation	Car parking, garages, locker rooms...	1

# C/AS1 - Exit routes

For the design of escape routes C/AS1 has a number of specific definitions.

IFC 2x only has one property relevant to escape route design and this is the ExitStair property in Pset\_StairCommon used by the IfcStair class.



It is clear that significant additions would be required to the IFC Model in order to incorporate the C/AS1 requirements and this could only be achieved by the addition of new sets for spaces and stairs.

Similar to the IFC Model, the Exitway property is used to define the escape route.

The IFC Model does not have a property to define the exit route.

The IFC Model does not have a property to define the exit route.



# C/AS1 - Material flammability

In addition to providing physical separations and the installation of fire safety systems, the control of internal fire and smoke spread can include an assessment of the burning characteristics of materials such as surface finishes to walls, floor coverings, suspended fabrics and acoustic or thermal insulation materials.

C/AS1 provides requirements for the burning characteristics of nearly all such materials through its spread of flame index (SFI), smoke developed index (SDI) and flammability index (FI).

IFC 2x only has one instance where material flammability is explicitly referenced and this is in the Pset\_Insulation property set with the FlamabilityRating property.

C/AS1 requires that pipe insulation and acoustic treatments only be assessed by their SDI and SFI and so the FlamabilityRating property has little use in conjunction with C/AS1.

Relevant elements in the IFC Model need to have new property sets in order to include the flammability requirements of C/AS1.

## C/AS1 - Dampers

Dampers are used to automatically close off an airway between fire-separated parts of a building.

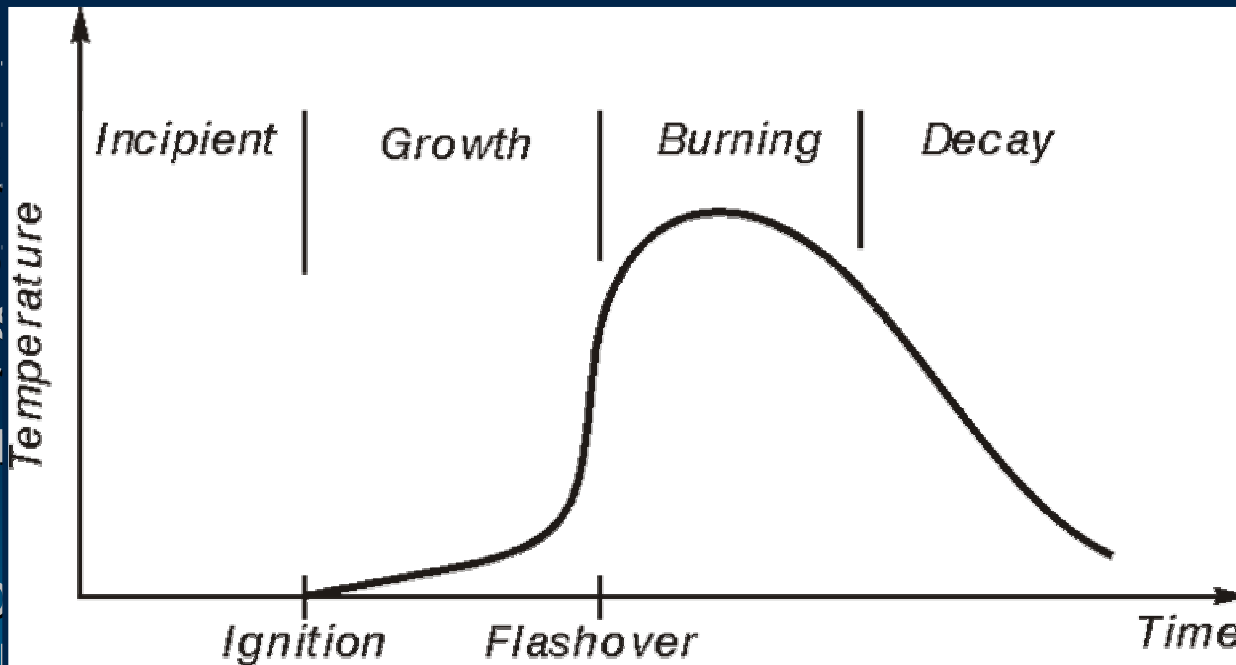
C/AS1 defines a fire damper and requires it has a specified FRR. IFC 2x includes properties for three types of fire-related damper all used by the IfcDamper class. The Pset\_FireDamper, Pset\_FireSmokeDamper both contain a property called FireResistanceRating.

Unlike the FireRating property for walls etc, this property is of type IfcReal which means it is not able to hold the “x/x/x” FRR classification required in C/AS1.

# Heat Release Property Set Definition

Where a fire engineer chooses to provide an alternative solution they will often need to examine the fire and smoke conditions in a building using a 'design fire curve'.

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# Heat Release Property Set Definition

- Data from a FireBaseXML database can be transformed to an appropriate IFC PSD through a specific XSL transformation.

- The Pset\_FurnitureHeatRelease PSD can be added to an IFC Model instance and assigned to one or more items of the heat release model instance, when transferring the building description into a fire modelling application.

IFC PS.0 Property Set Definition Reference

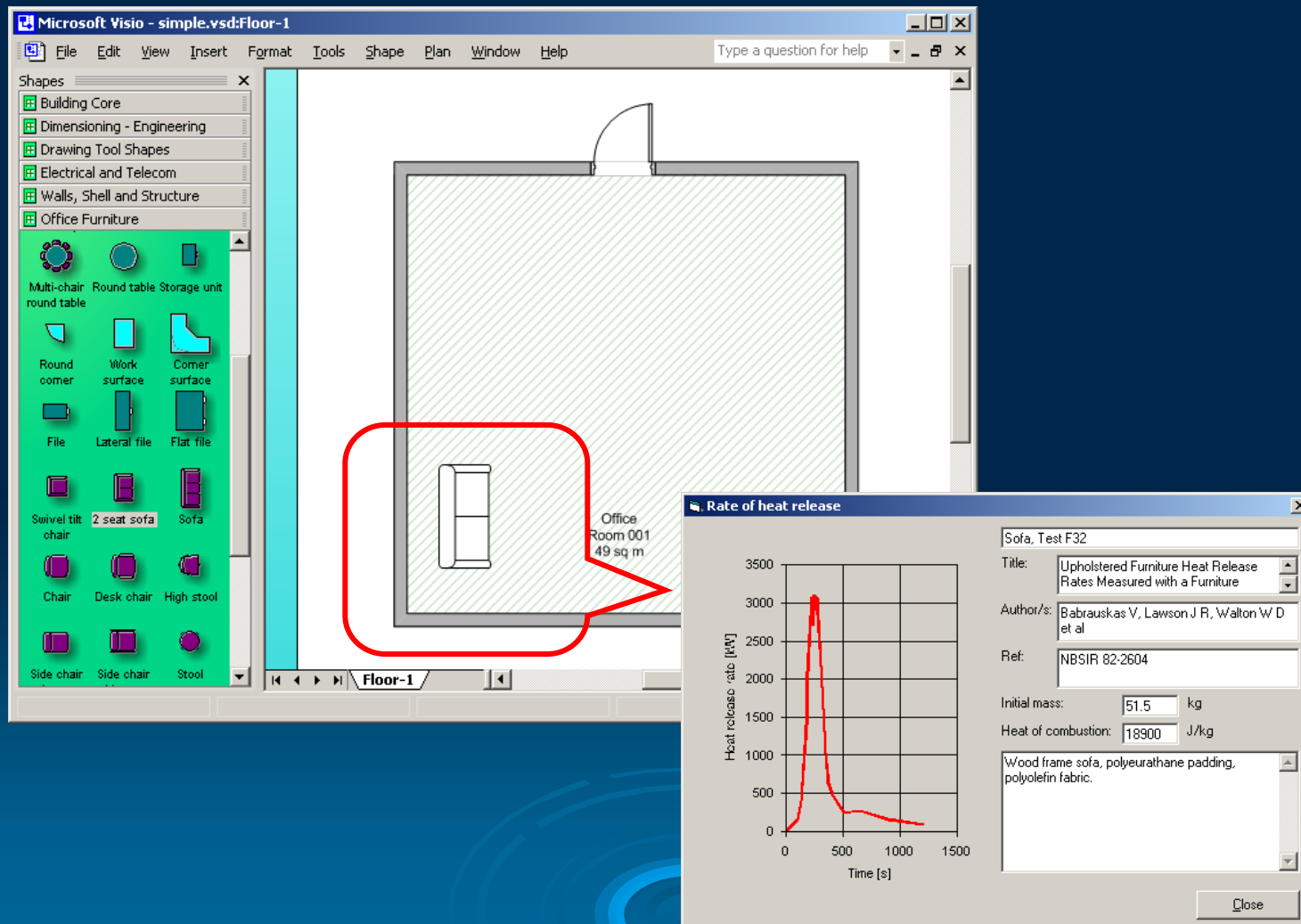
Property Set Definition:

PropertySet Name	Pset_FurnitureHeatRelease
Typed	False
TypedClass	
TypeName	
Definition	Definition from MJS, University of Canterbury

Property Definitions:

Name	Property Type	Data Type	Definition
HeatOfCombustion	IfcPropertySingleValue	IfcReal / UserDefined	The average heat of combustion
RateOfHeatRelease	IfcPropertyTableValue	<b>Defining Value:</b> IfcTimeMeasure / TIMEUNIT  <b>Defined Value:</b> IfcEnergyMeasure / ENERGYUNIT	Time series rate of heat release
OriginalTestID	IfcPropertySingleValue	IfcText	The original ID of the test taken from the FireBaseXML database

# IFC exchange process into the FAST fire model



# Conclusions

The current IFC 2x model provides much general information useful to the fire engineer.

The fire specific properties that currently exist in the IFC Model have limited scope when compared to the needs of fire engineers and the ability of the properties to describe the New Zealand C/AS1 requirements.

Property Set Definitions can be used to extend the IFC Model so as to include additional fire-related properties.