Sustainable Building Design and Fire Safety Issues and Opportunities

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Acknowledgments

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Outline

- what is a sustainable or “green” building
- sustainable features of buildings
- background and literature
- sustainable building features and affect on fire safety
- ranking features and fire safety using an expert group
- CFD modelling of double skin facades
- Summary

Introduction

- There is a growing demand for building green or sustainable buildings
- A well-designed building must meet other design objectives such as usability, aesthetics, potential for redesign for alternative uses and safety.
- A building should achieve a reasonable level of fire safety and there are statutory requirements that also must be met.
- Sustainable building features have an affect on fire safety that may differ from traditional alternatives

This Study 2012

- focused on sustainable building features
  - whether or not a building was rated as a “green” building
- looked at common features that are good for the environment

Background and Literature

- relatively little published work on green buildings and fire

  BRE 2709 (2010) *Impact of fire on the environment and building sustainability* BD 2709.

  The International FORUM of Fire Research Directors: A Position paper on Fire Safety and Sustainability (2012)

  Tidwell and Murphy 2010 Bridging the Gap–Fire Safety and Green Buildings.

  Robbins 2012 Building Sustainability and Fire-Safety Design Interactions: Scoping Study.

  Meacham et al. 2012, Fire Safety Challenges of Green Buildings.

Sustainable building features and affect on fire safety

- Robbins identifies 91 sustainable building features
- Meacham et al. lists over 70 sustainable building features
- so not all can be discussed here
- focus on more common and more significant ones

Sustainable building features and affect on fire safety

- most fire risks pretty obvious
- requires some engineering to be done
- is there an increased fire risk?
- how can the increased risk be mitigated?
- or is the increase in risk too small, or other benefits too big to do anything?

VUW Study 2012.

Number of Features Used into Green Buildings		
Building Features	Total	Percentage
Sustainably Sourced Materials	50	100%
Recyclable Materials	50	100%
Rainwater Harvesting System	50	100%
Lower Energy Mechanical Ventilation System	20	40%
Atrium	19	38%
Double Skin Facade	7	14%
Green Roof	6	12%
Local Power Generation	6	12%
Storage Area for Recyclables	4	8%

- 54 commercial buildings received green star ratings in New Zealand between 2007 and 2012
- information on 50 buildings could be accessed

Sustainably Sourced, Recyclable and Alternative Materials

- Self explanatory
- if they are more flammable than the alternative then they have a higher fire risk

- but alternative may be more flammable or toxic
  - e.g. plastics or foamed plastics

Shanghai 15 November 2010

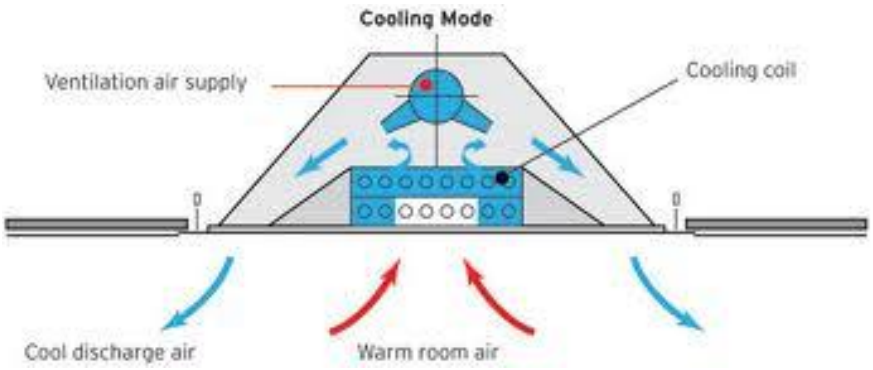
- fire spread through external polystyrene insulation
- product such as rock wool or glass fibre would have been safer

Lower Energy Mechanical Ventilation Systems

- many different types
  - distributed heating and cooling
  - zoned local control of heating and cooling
  - low velocity, high volume fans
  - variable air volume fans
  - ventilation rate controlled by air monitoring
    - e.g. carbon dioxide
- all change the way air and hence smoke will move around a building
- all provide opportunity for smoke control
  - Enhancing life safety
  - Reducing damage to equipment from acid in smoke

Distributed Heating and Cooling

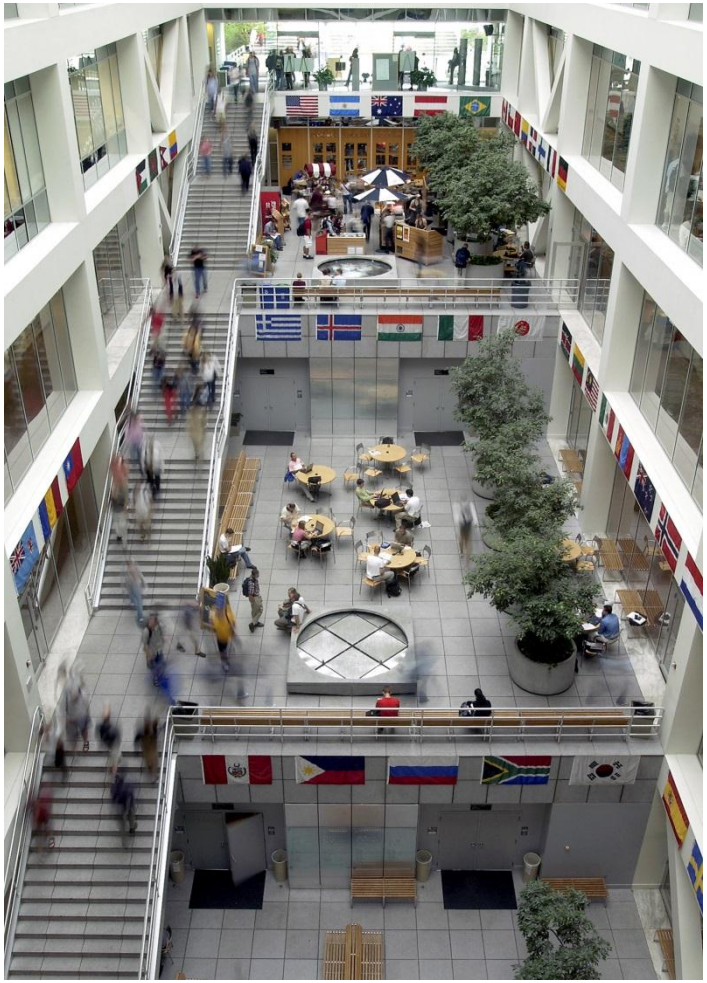
- central HVAC plant pumps large amounts of hot or cold air around a building
  - much more air than required for ventilation
  - the more air it can move, the more smoke it can move
- distributed heating and cooling
- e.g. chilled beams
  - reduced air flow
  - less smoke flow



Zoned Systems

- controlled to only ventilate and heat or cool spaces that need it
- usually controlled by motorised dampers in ductwork
  - dampers can also be interfaced with fire and close when the alarm is activated to prevent smoke spread

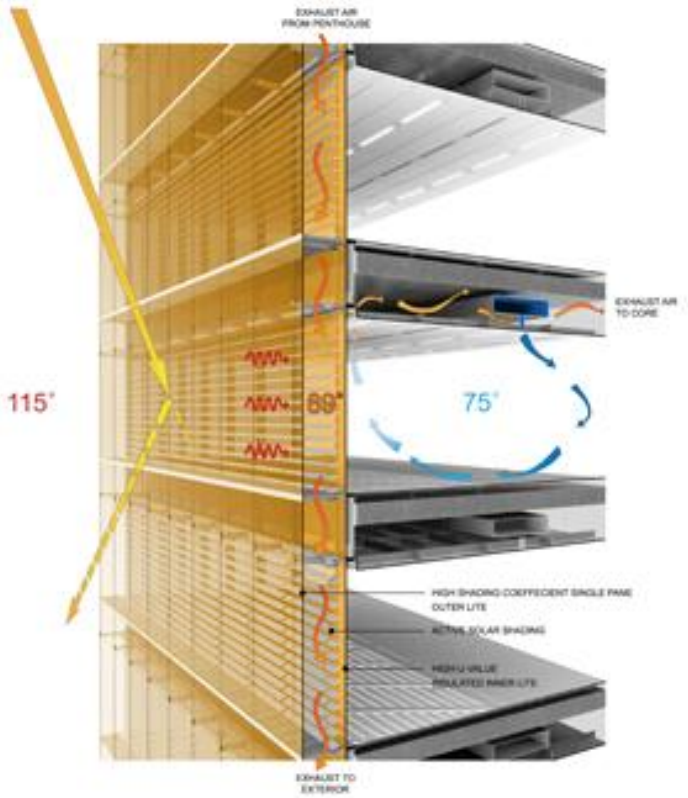
Atria



- used for natural light
- and passive ventilation
- obviously allows for passage of smoke and fire between floors
- smoke control system is therefore necessary

Double Skin Facades

- used to control thermal (heat) gain from sunlight
- provide thermal insulation
- and passive ventilation
- and passive heating/cooling
- obviously allows for passage of smoke and fire between floors
- how can this be prevented or minimised?



Local power generation

- currently
  - photovoltaic (PV) panels
  - wind turbines
- future
  - fuel cells
  - bioreactors, nuclear, ?

- both are flammable
- potential ignition sources
- add structural load to the building
- could hinder fire fighter access
- could hinder smoke/heat venting by opening roof

Bakersfield
California
April 29, 2009

- fire in photovoltaic panels due to ground fault
- local power generated systems must be able to be isolated from the fire service access point

Storage area for recyclables

- many recyclables are combustible
- some have very rapid fire growth rates and/or produce toxic fumes
- control and limit storage
- fire rate large storage areas from habitable parts of the building

Insulation and Phase Change Materials

- more insulation means less energy use
  - but many lightweight insulation products are highly combustible
- Phase Change Materials
  - used to store heat energy as the latent heat of melting absorbs large amounts of heat energy, which can be released when the material re-solidifies
  - most common types are paraffin wax and organic fatty acids which are both highly flammable

Ranking features and fire safety using an expert group

Ranking of Sustainable Features and Fire Safety

- little experience and literature
- an expert panel of fire engineers was formed
- The panel was sent a survey and then interviewed in depth.
- They were asked to rank the risk of the ten common sustainable features found previously in New Zealand “green” buildings, based on
  - potential fire safety issues,
  - risk
  - knowledge of, and availability of mitigation measures

Ranking of Sustainable Features and Fire Safety

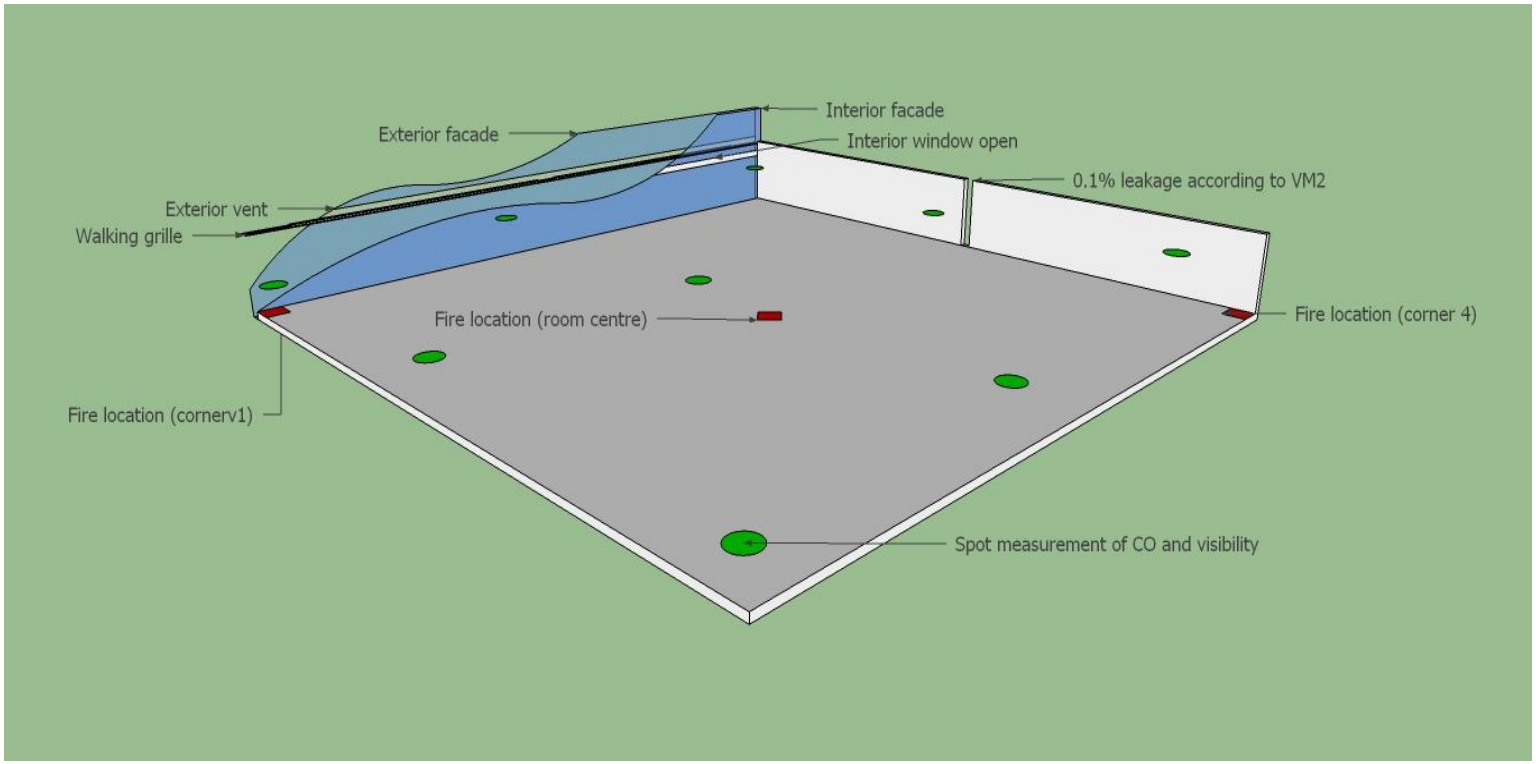
- Double skin faces were ranked by the expert panel as the highest risk, closely followed by atria, then storage of recyclables
- However the panel believed that mitigation measures for atria, and storage of recyclables are well understood and readily implemented
- and there are potential fire safety issues with double skin facades with limited knowledge of what they are and how they can be dealt with
- so it was decided do investigate double skin facades further.

CFD Modelling Of Double Skin Facades

CFD Modelling Of Double Skin Facades

- Using Computational Fluid Dynamics (CFD), model Fire Dynamics Simulator Version 5 (FDS5).
- Modelling was carried out in accordance with New Zealand Building Code Compliance Document C/VM2, Framework for Fire Safety Design

CFD Modelling Of Double Skin Facades



- Two prototype buildings modelled.
  - 3 storey building 60m by 60m with 1m double skin facade on 1 side with sprinklers installed
  - 3 storey building 30m by 30m with 1m double skin facade on 1 side with and without sprinklers

Vent Parameters Modelled

- combinations of vents at the top and outside of the DSK were modelled, along with different fire locations, and closed and half-open interior vents, 0.5m and1.0m cavities, sprinklered and unsprinklered

	Detection System	Fire location	Interior facade opening area	Exterior facade	Top opening of DSF frame	Cavity width
Base model	Smoke detector	Room centre	25%	Closed	Closed	0.5m
Scenario 1	Smoke detector	Corner 1	25%	Closed	Closed	0.5m
Scenario 2	Smoke detector	Corner 4	25%	Closed	Closed	0.5m
Scenario 3	Automatic fire sprinkler	Room centre	25%	Closed	Closed	0.5m
Scenario 4	Smoke detector	Room centre	Closed	Closed	Closed	0.5m
Scenario 5	Smoke detector	Room centre	12.50%	Closed	Closed	0.5m
Scenario 6	Smoke detector	Room centre	25%	Open	Closed	0.5m
Scenario 7	Smoke detector	Room centre	25%	Closed	Open	0.5m
Scenario 8	Smoke detector	Room centre	25%	Closed	Closed	1.0m
Scenario 9	Smoke detector	Room centre	25%	Closed	Open	1.0m
Scenario 10	Smoke detector	Room centre	25% (1st level only)	Closed	Open	0.5m
Scenario 11	Smoke detector	Room centre	25% (1st level only)	Closed	Open	1.0m
Scenario 12	Smoke detector	Room centre	25%	Open	Open	0.5m
Scenario 13	Automatic fire sprinkler	Room centre	25%	Open	Open	0.5m

Summary of CFD Results

- If the facade has vents to the outside open, then visibility on upper floors is maintained for long enough to permit escape
  - supported by findings of Deng, Hasemi, and Yamada
- if the vents to the outside from the DSF are closed or do not exist, then it is unlikely that visibility on upper floors will be maintained for long enough to permit escape
- if the building is fitted with an automatic sprinkler system that controls the fire, then visibility on upper floors is likely to be maintained for long enough to permit escape regardless of whether vents are open or closed

Recommendations for DSF

- Install automatic sprinklers throughout the building
- Install larger vent areas to outside than inside
  - separate the controls and power supplies for the internal and external vents to the DSF,
- or both the above

Summary

- More buildings will be built with sustainable features
- Some of these features have fire safety issues which need to be addressed
- Some building codes will limit their use
- most of these issues are obvious as are methods to mitigate the risk
- Some of these features will, or can be used to, improve fire safety