

IRUSE & The Ryan Institute @ NUIG - 24th June 2013
Built Environment Research Networking Workshop



9-11 Ruins of WTC Building 7

Collapse Level Event (CLE)

Towards a Safe Sustainable Climate Resilient Built Environment ...

Sustainable Fire Engineering Design



FireOx International

www.cjwalsh.ie

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Current European Commission Policies ?



COM(2013) 169 final - Green Paper: A 2030

Framework for Climate & Energy Policies

The European Commission has lost the plot ... big time !

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1. Creative Fire Engineering Concepts and Building Systems
 2. Fire-Induced Progressive Damage in Buildings
 3. Human Behaviour and Abilities in a Fire Situation
 4. Building Design for Firefighter Safety
 5. BMS, Fire Modelling & BIM



Sustainable Fire Engineering Design

◆ 'Reliability-Based'

... the design process is based on competence, practical experience, and an examination of 'real' fire incident data and extreme events, e.g. **2001 WTC 9-11 & 2008 Mumbai Attacks**, and **2011 Fukushima Nuclear Incident** ... rather than theory alone ;

◆ 'Person-Centred'

... 'real' people are placed at the centre of creative endeavours and proper consideration is given to their responsible needs ... and their health, safety, welfare and security in the **Human Environment** ;

◆ Adapted to Local Context & Heritage*

... geography, orientation, climate (incl. change, variability and severity swings), social need, culture, economy, building crafts and materials, etc., etc ;

[*see ICOMOS 2011]



◆ Fire Engineering Research

... must be targeted at practical implementation in 'real' buildings ... with actual user/construction performance carefully (i.e. reliably and precisely) monitored.



Modern Architecture

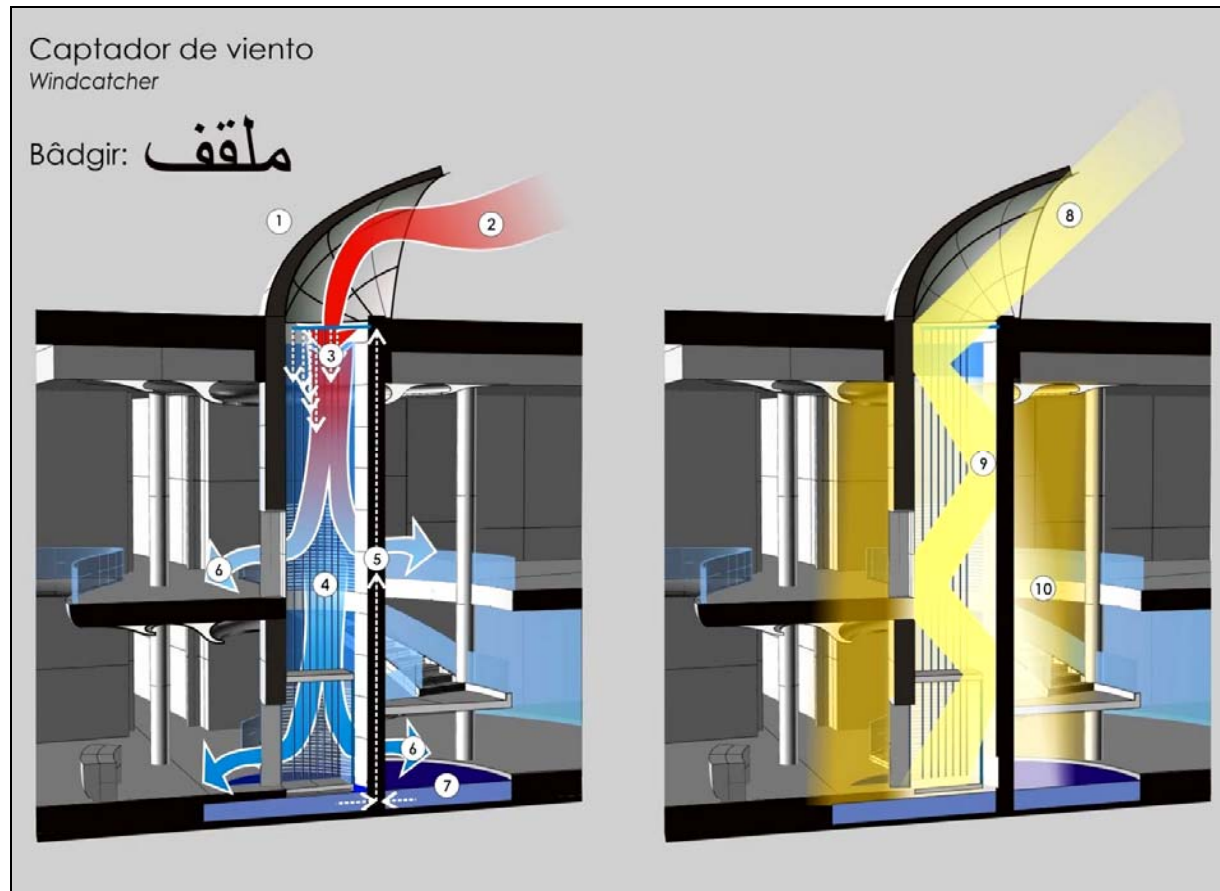
Innovative Construction Materials & Open Plan Design
Separate Articulation of Structure & Fabric ... Development of Structural Systems



Mies van der Rohe - Barcelona Pavilion (1929)



Sustainable Buildings



Project by Orlando De Urrutia, Architect - Spain

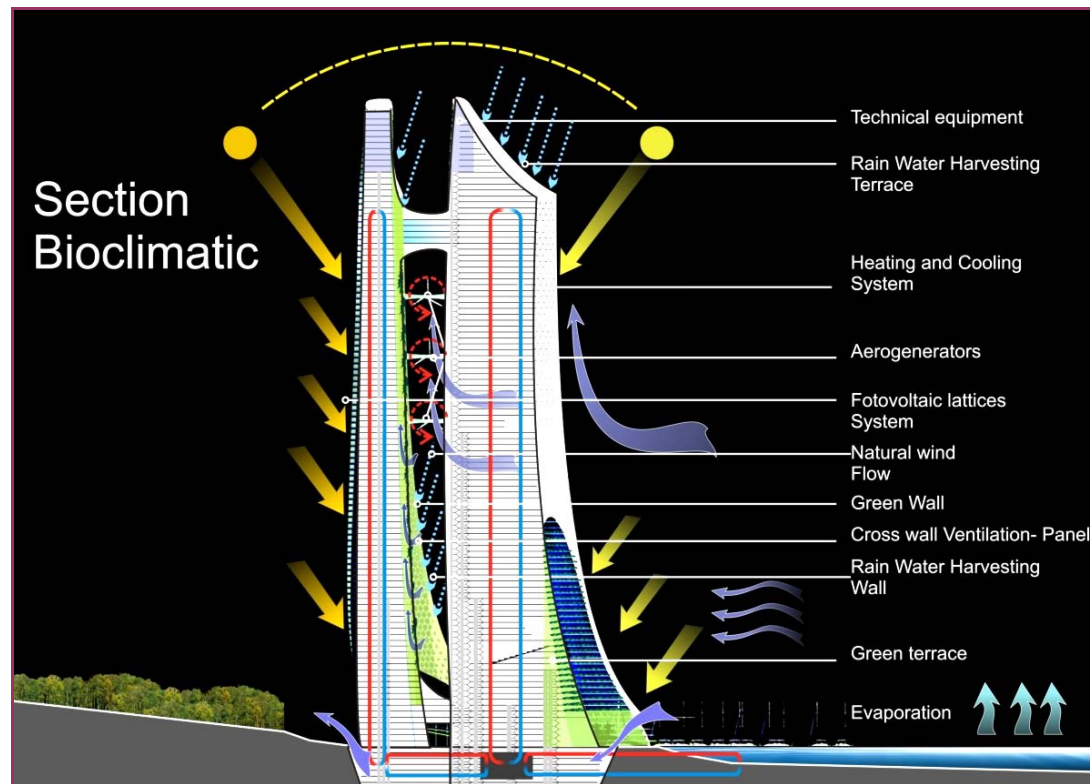


New Design Language of Sustainability

Complex Spatial Planning and Architectural Design Concepts ... Non-Traditional Building Forms, Construction Products and Systems

No Compartmentation in Buildings in order to use Natural Patterns of Air Movement for Heating and/or Cooling

'Positive Energy Buildings' producing far more energy than they need ... Excess returned to Regional or Local Intelligent Grids



Project by Orlando De Urrutia, Architect - Spain



Historical Buildings

Heavy Masonry Construction & Highly Compartmented for Functional Reasons
Fabric IS Structure ... Single Isolated Structural Elements (beams spanning over door/window openings, large rooms)
Isolated Beams ... Concern with Excessive Deflection and Failure ... Material Strength



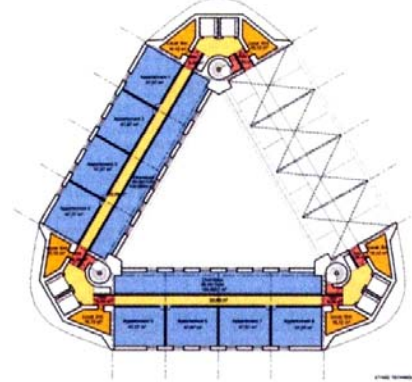
Palace of Versailles - Near Paris, France



Safer Structural Forms: stability+evacuation



Multi-Core Design



Super Tall

Buildings

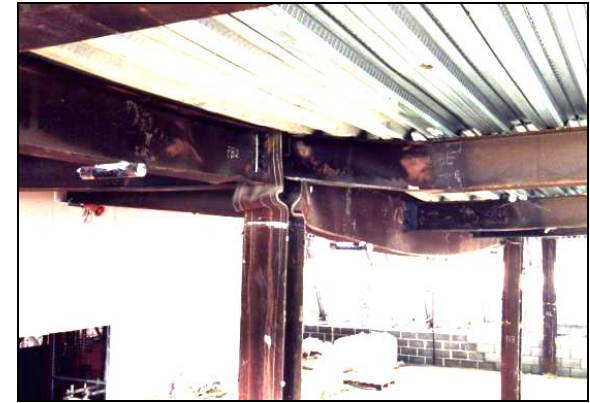
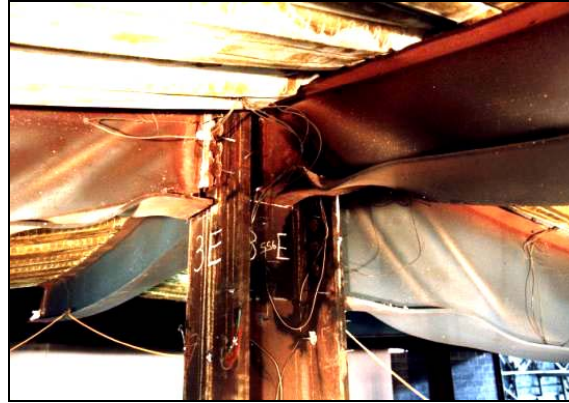


Denis Sloan, architecte; Peter Terrell et Geoff Rooke, ingénieurs structures; et Claude Delalande, ingénieur sécurité (ex-Officier BSPP, Paris-Expo) - France.

2005 NIST(USA) Final Report on 9-11 WTC 1 & 2 Tower Collapses, Recommendation 18



1990's Steel Frame Test Fire Failures



In a New Project ... will connections be sufficiently robust under fire conditions ?

What maximum beam and column deformations will be permissible ?

Will the whole frame remain structurally reliable ? Will adjoining fire resisting non-structural fabric still function ?



Disproportionate Damage

The failure of a building's structural system ...

- (i) remote from the scene of an isolated overloading action ; and
- (ii) to an extent which is not in reasonable proportion to that action.

NIST Priority Buildings: High-Rise + Iconic + Critical Function + Innovative Design

CIB W14 WG IV: Both are Fundamental Concepts in all Structural Fire Engineering !

Fire-Induced Progressive Damage

The sequential growth and intensification of structural deformation and displacement, **beyond fire engineering design parameters**, and the eventual failure of elements of construction in a building – during a fire and the 'cooling phase' afterwards – which, if unchecked, will result in disproportionate damage, and may lead to total building collapse.

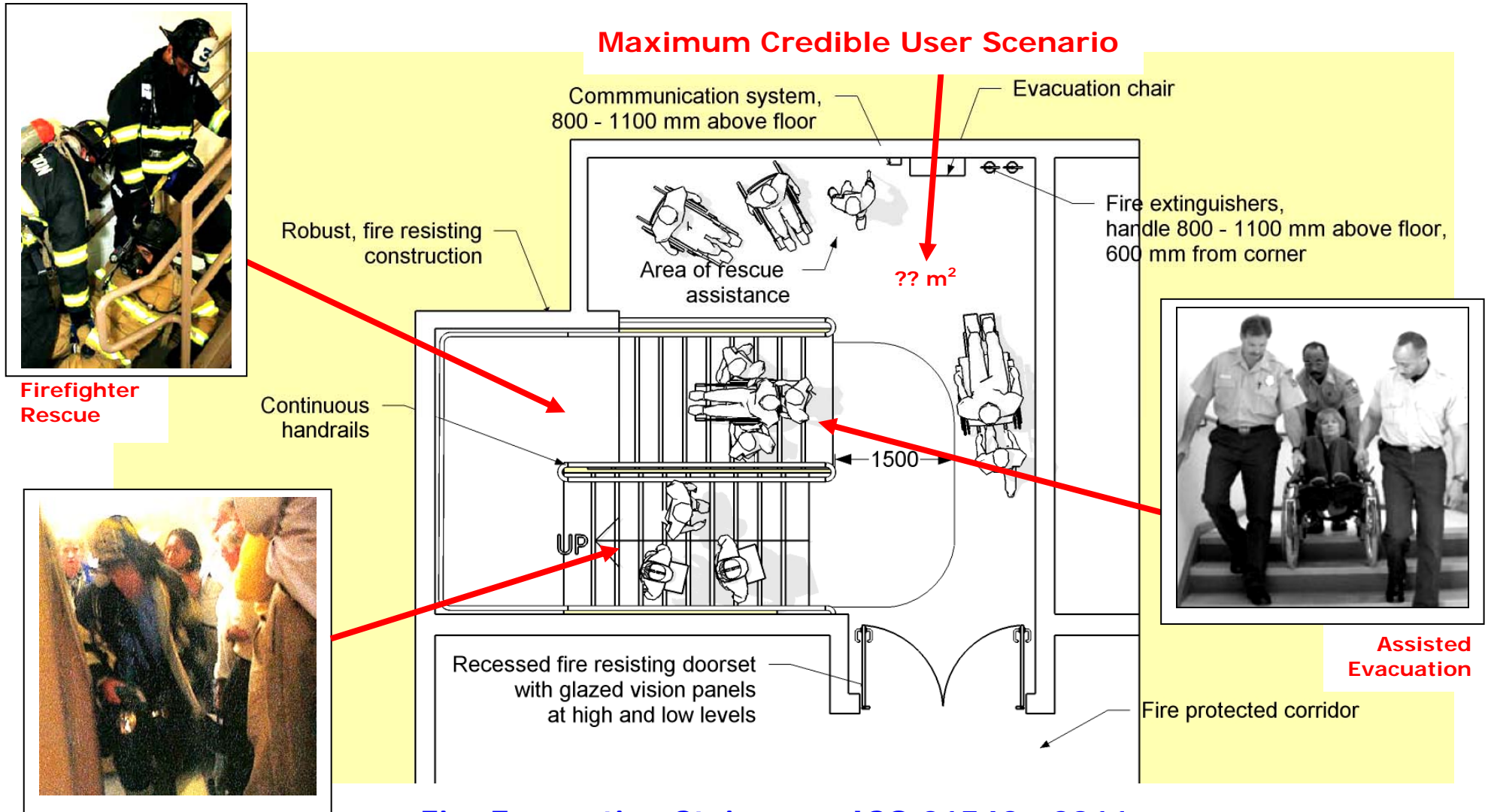
Fire Serviceability Limit States !



Specifying Steel Fire Protection Systems

1. Check that the Fire Protection System is shown to be 'Fit for its Intended Use' ... including 'durability' & 'resistance to mechanical damage' during construction and in a fire situation.
2. Check Robustness of Connections ... will they withstand the deformation effects of connected steel structural elements in a fire situation ?
3. Check Whole Frame Structural Reliability in a fire situation ... develop a Frame Structural Reliability Matrix
4. Check Fire Resisting Non-Structural Fabric ... adjoining and/or adjacent to steel structural elements
5. Specify Thermal Insulation Thicknesses to ensure steel deformations remain within Fire Engineering Design Parameters !!





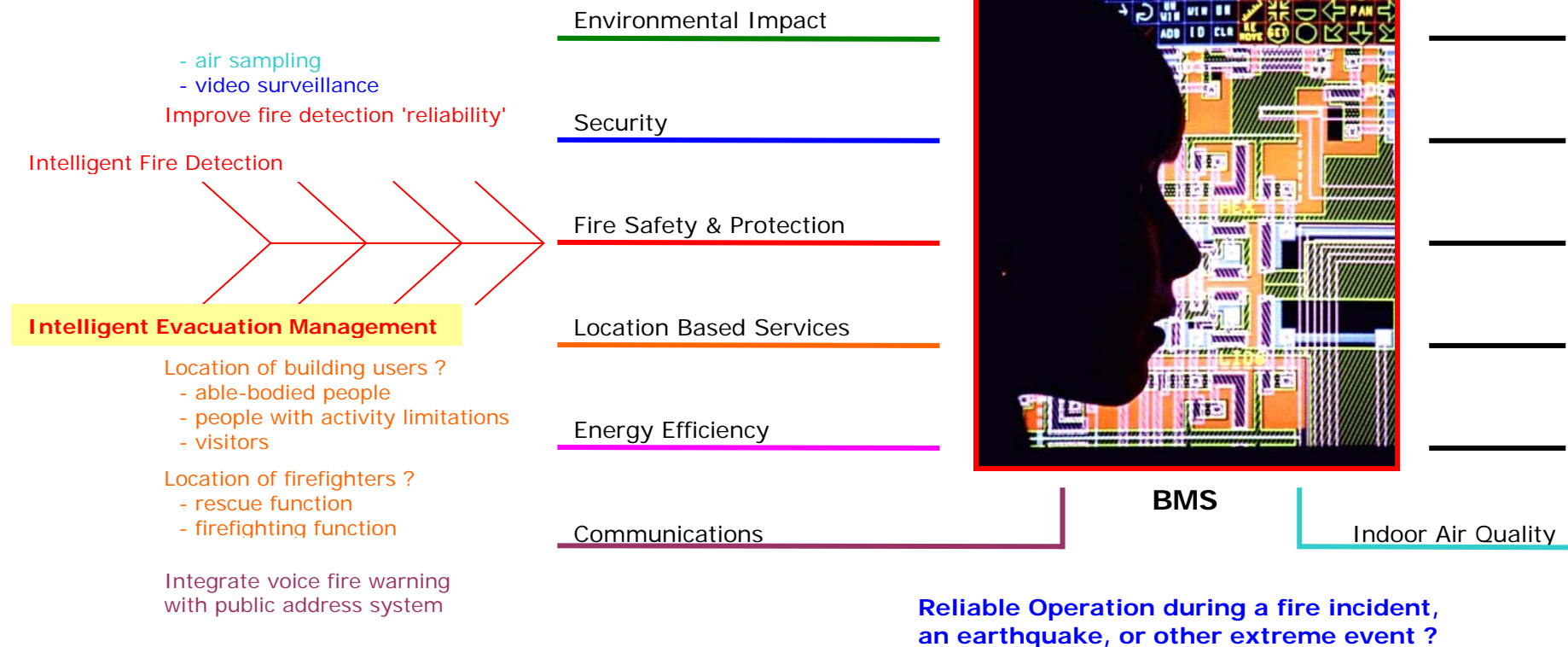
[All lifts/elevators in a building should also be used for fire evacuation]



Intelligent Evacuation Management

Large Scale Application of Full BMS (Building Management System) Integration:

Accessible Building User Interface Technologies



BMS, Fire Modelling & BIM ?

Building Management Systems ?

Actual construction **and** user performance must be carefully (i.e. reliably and precisely) monitored in **All** Sustainable Buildings ... using permanently installed devices !

Fire Modelling ?

The expected outcome of a Computer Model Verification and Validation (V&V) Process ... a very problematic issue within the International Fire Science and Engineering Community ... is a quantified level of agreement between experimental data (and when available, 'real' fire incident data) and model prediction ... as well as a quantified model predictive accuracy.

The WTC 9-11 Attacks have provided a wealth of 'real' data ... which is being widely ignored !

Post Priory Hall in Dublin ... Computer Models can no longer be 'black boxes' ! Proper transparency must be considered at the earliest stages of development ... 'glass boxes' !!

Building Information Modelling ?

A tremendous amount of waste is associated with, and generated by, the processes of conventional building design, construction, and servicing. BIM is a more effective and efficient way of doing things ... an essential way for Sustainable Design !

BUT ... basic level Fire Engineering must be integrated into BIM Software !!



Maximum Credible User Scenario

Represents user conditions which are severe but reasonable to anticipate ...

- (a) **10% of People Using the Building have an Impairment** (occupants, visitors and other users) ... visual, hearing, physical function, psychological, mental, or cognitive, with some impairments not being identifiable (stigma, and anosognosia) ;

[refer to **ISO 21542: 'Building Construction - Accessibility & Usability of the Built Environment'**]

- (b) The Number of People Using a Building increases, on occasions which cannot be specified, to **120% of calculated maximum building capacity**.

2005 NIST(USA) Final Report on 9-11 WTC 1 & 2 Tower Collapses Recommendations 4 and 9

NIST recommends the development of standards and code provisions to enable the design and retrofit of structures to resist 'real' building fire conditions, including their ability to achieve the (fire engineering design) objective of burnout in a **Maximum Credible Fire Scenario**, without structural or local floor collapse ... recognizing that sprinklers could be compromised, not operational, or non-existent.

Footnote 26: A **Maximum Credible Fire Scenario** includes conditions which are severe, but reasonable to anticipate, conditions related to building construction, occupancy, fire loads, ignition sources, compartment geometry, fire control methods, etc., as well as adverse, but reasonable to anticipate, operating conditions.



Building Design & Safe Evacuation-for-All

- Design - 'Intuitive & Obvious'

[2005 NIST(USA) Final Report on the 9-11 WTC 1
& 2 Tower Collapses, Recommendation 18]

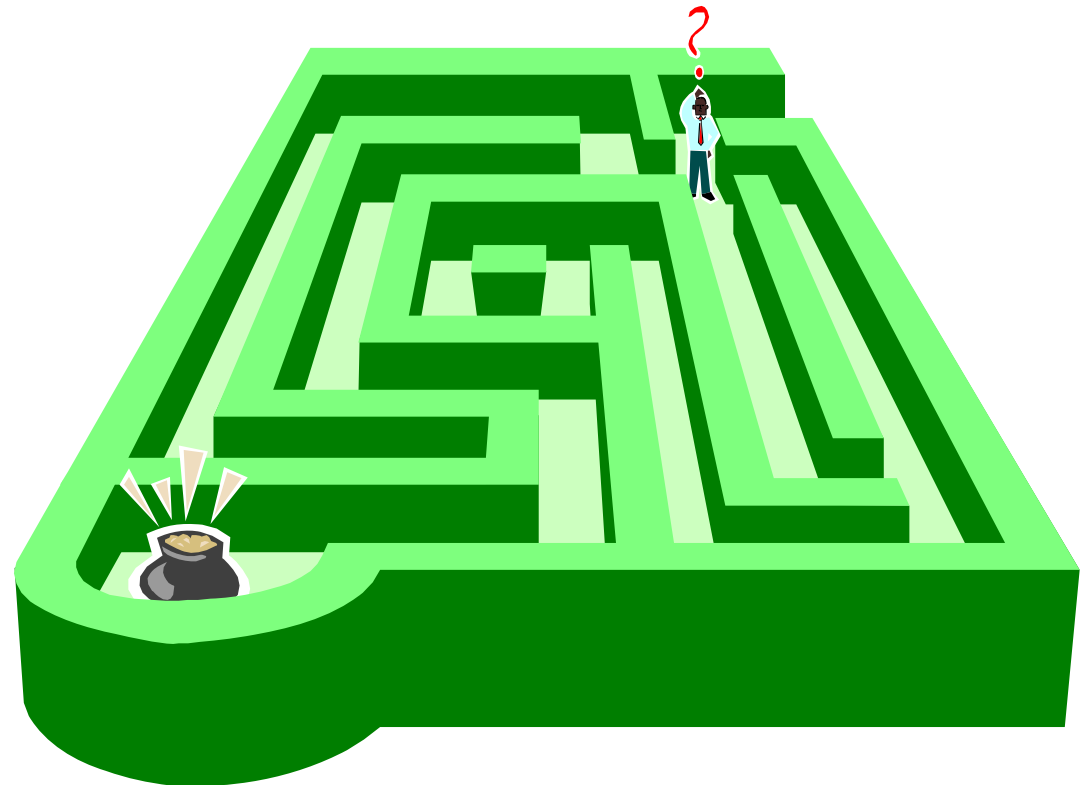
- Building Understandability

- Visual Spatial Learning /
Proprioception (6th sense)

- User Evacuation Skills

- Cognitive Psychology

- Firefighter Safety ...
e.g. disorientation,
communications failure



" W-h-e-r-e is the final exit ? "



People with Cognitive Impairments

January 2002 - Dún Laoghaire Shopping Centre, Ireland



People with Psychological Impairments

April 2007 - Hotel Meliá Santiago de Cuba, Cuba



Appendix



A Sustainable 'Human' Environment

Social Environment

The complex network of real and virtual human interaction - at a communal or larger group level - which operates for reasons of tradition, culture, business, pleasure, information exchange, institutional organization, legal procedure, governance, human betterment, social progress and spiritual enlightenment, etc.

The **Social Environment** shapes, binds together, and directs the future development of the Built and Virtual Environments.

Built Environment

Anywhere there is, or has been, a man-made or wrought (worked) intervention by humans in the Natural Environment, e.g. cities, towns, villages, rural settlements, service utilities, transport systems, roads, bridges, tunnels, and cultivated lands, lakes, rivers, coasts, seas, etc ... including the Virtual Environment.

Economic Environment

The intricate web of real and virtual human commercial activity – operating at micro and macro-economic levels – which facilitates, supports, but sometimes hampers or disrupts, human interaction in the Social Environment.



European Union

Regulation (EU) No. 305/2011 of the European Parliament and of the Council, of 9 March 2011, laying down Harmonized Conditions for the Marketing of Construction Products and Repealing Council Directive 89/106/EEC

ANNEX I - 'Basic Requirements for Construction Works' 1 & 2 (of 7) ...

1. Mechanical Resistance & Stability

The construction works must be designed and built in such a way that the loadings that are liable to act on them during their construction and use will not lead to any of the following:

- (a) collapse of the whole or part of the works ;
- (b) major deformations to an inadmissible degree ;
- (c) damage to other parts of the construction works or to fittings or installed equipment as a result of major deformation of the load-bearing construction ;
- (d) damage by an event to an extent disproportionate to the original cause.

2. Safety in Case of Fire

The construction works must be designed and built in such a way that in the event of an outbreak of fire:

- the load-bearing capacity of the construction can be assumed for a specific period of time ;
- the generation and spread of fire and smoke within the construction works are limited ;
- the spread of fire to neighbouring construction works is limited ;
- occupants can leave the construction works or be rescued by other means ;
- the safety of rescue teams is taken into consideration.



European Union (contd.)

ANNEX I - 'Basic Requirements for Construction Works' 3, 4 & 7 ...

3. Hygiene, Health and the Environment

The construction works must be designed and built in such a way that they will, throughout their life cycle, **not be a threat to the hygiene or health and safety of workers, occupants or neighbours, nor have an exceedingly high impact, over their entire life cycle, on the environmental quality or on the climate during their construction, use and demolition**, in particular as a result of any of the following:

(b) the emissions of dangerous substances, volatile organic compounds (VOC's), greenhouse gases or dangerous particles into indoor or outdoor air ;

4. Safety and Accessibility in Use

The construction works must be designed and built in such a way that they do not present unacceptable risks of accidents or damage in service or in operation such as slipping, falling, collision, burns, electrocution, injury from explosion and burglaries. **In particular, construction works must be designed and built taking into consideration accessibility and use for disabled persons.**

7. Sustainable Use of Natural Resources

The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:

(a) re-use or recyclability of the construction works, their materials and parts after demolition ;
(b) durability of the construction works ;



People with Activity Limitations (En) Personnes à Performances Réduites (Fr)

Those people, of all ages, who are unable to perform, independently and without aid, basic human activities or tasks - because of a health condition or physical / mental / cognitive / psychological impairment of a permanent or temporary nature.

This definition is derived from the World Health Organization's International Classification of Functioning, Disability & Health (ICF), which was adopted on 22 May 2001.

The above **Terms** (in English and French) include ...

- a) wheelchair users ;
- b) people who experience difficulty in walking, with or without a facilitation aid, e.g. stick, crutch, calliper or walking frame ;
- c) frail, older people ;
- d) the very young (people under the age of 5 years) ;
- e) people who suffer from arthritis, asthma, or a heart condition ;
- f) the visually and/or hearing impaired ;
- g) people who have a cognitive impairment disorder, including dementia, amnesia, brain injury, or delirium ;
- h) women in the later stages of pregnancy ;
- i) people impaired following the use of alcohol, other 'social' drugs e.g. cocaine and heroin, and some medicines ;
- j) people who suffer any partial or complete loss of language related abilities, i.e. aphasia ;
- k) people impaired following exposure to environmental pollution and/or other irresponsible human activities, e.g. war and terrorism ;

and ...

- l) people who experience a panic attack in a fire situation or other emergency ;
- m) people, including firefighters, who suffer incapacitation as a result of exposure, during a fire, to poisonous or toxic substances, and/or elevated temperatures.

