Multi-Storey Commercial Buildings in Steel

SCI
Steel Knowledge

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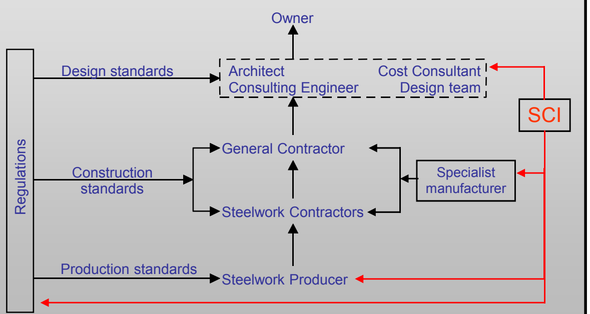
SCI Director
Kiev, 6 November 2013

SCI

- Established in 1986 to promote the effective use of steel in construction
- Independent member-based organisation
- Staff of 40

UK Construction Supply Chain



Activities

- Membership
- Technical Information
  - Publications
  - Codes and standards
  - Courses
- Projects
  - Research and Development – Typically new products
  - Engineering Software – Product specific
  - Specialist consultancy – Fire engineering, vibrations, etc.
  - Independent assessment – Product quality

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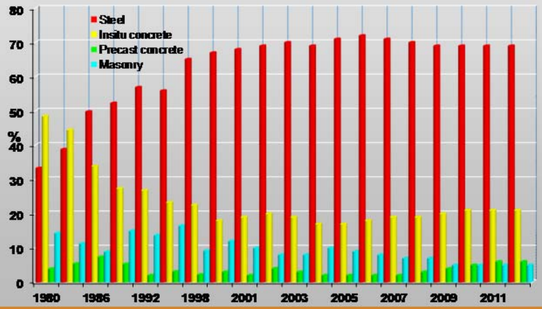
Multi-storey Buildings in the UK



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Economic Benefits of Steel Construction in Multi-Storey Buildings

- Speed - 20 to 30% reduction in construction time relative to site-intensive construction
- Site management costs – 20 to 30% leading to 3-4% saving in overall building cost
- Service integration - reduction of 100-300mm in floor to floor zone and savings in cladding cost
- Foundations - 30% reduction in overall foundation loads compared with R.C.
- Column free space - more flexible use of space

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Multi-Storey Office Buildings

- Framing
- Floor systems
- Service integration
- Fire resistance

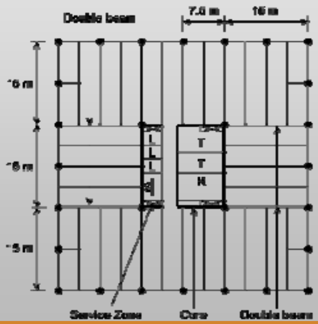
Structural Form

- Braced frame
  - Steel bracing – buildings up to 6 storeys high
  - Concrete core – building >6 storeys
- Continuous frame (moment connections)
  - Used in buildings up to 4 storeys
  - Typically where bracing needs to be eliminated due to highly glazed facades

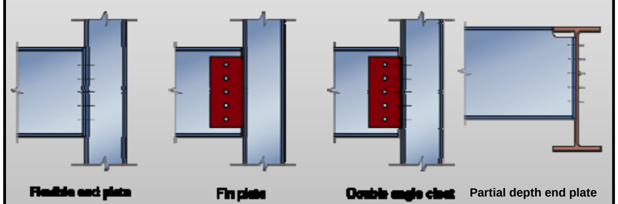
Braced Frame – steel bracing

Braced Frame – concrete core

Braced Frame – Concrete Core



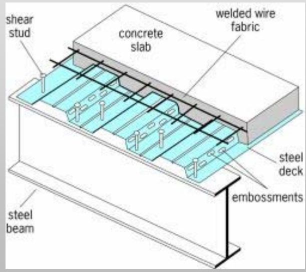
Braced Frame - connections



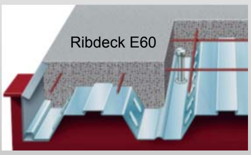
- Simplicity
- Standardisation

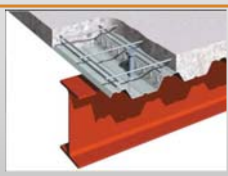
Composite Floor Construction

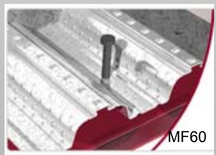
- Composite decking
  - Shallow decking
  - Deep decking
- Composite beams
  - Downstand beams
  - Shallow floor solutions
  - Long span solutions



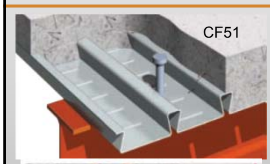
Trapezoidal Composite Decking

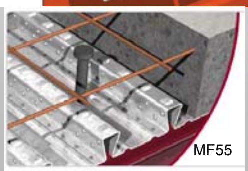


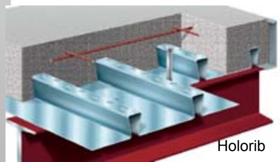




“Re-entrant Corner” Composite Decking

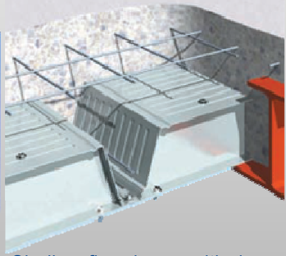






Deep Decking

Downstand composite beam with composite shallow deck

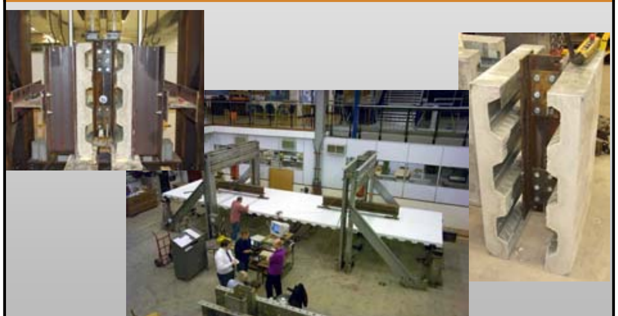


Shallow floor beam with deep composite deck

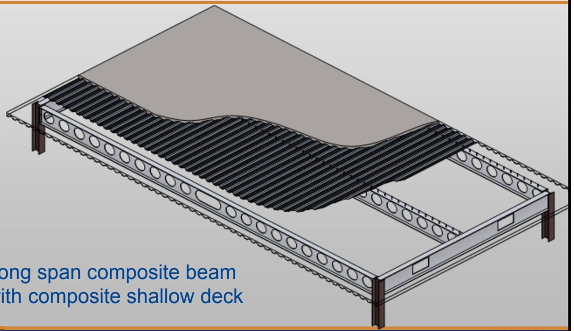
Deck Span Ranges

Deck Profile	Span (m)	Slab Depth (mm)
≤ 50 mm	2.5 – 3.2	100 – 130
50 – 60 mm	3.2 – 3.8	130 – 150
80 mm	3.8 – 4.5 m	150 – 180
146 mm	5.0 – 6.5 m	215 – 305
225 mm	5 – 8 m	300 - 350

Performance Verified by Testing

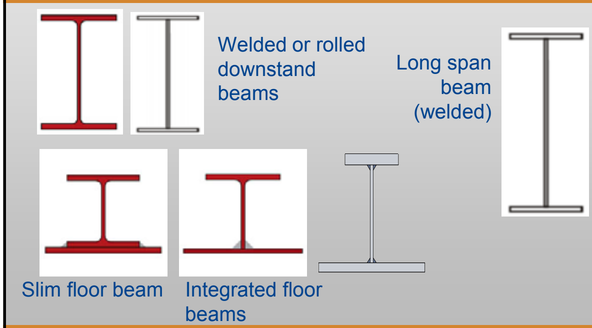


Long Span Composite Floors

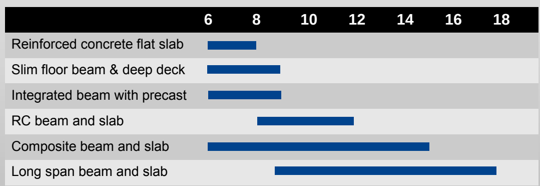


Long span composite beam
with composite shallow deck

Steel Beams in Composite Floors



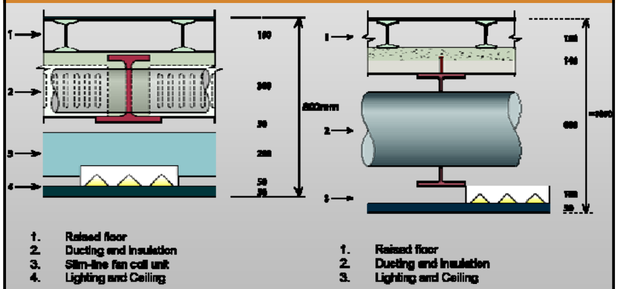
Typical Span Ranges



Advantages of Composite Construction

- Composite beams are stronger and stiffer than steel beams
  - Steel weight reduced by typically 30 to 50%
  - Reduction in beam depth (span:depth ≈ 25)
  - Lightweight construction
  - Improved vibration and fire resistance
- Coposite slabs are more efficient than RC slabs
  - Decking acts as working platform
  - Decking stabilises the beams
  - Composite slabs are fire resistant

Service Integration



Typical for 7.5m span

Typical for 15m span

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UK Fire Resistance Requirements

Table A.2 of Approved Document B

Maximum height, m.	Approximate number of storeys	Office	
		Without Sprinklers	With Sprinklers
> 30m		Not Permitted	120
≤ 30m	10	90	60
≤ 18m	6	60	30
≤ 5m	1 to 2	30	30

Fire resistance period: time required for a building to retain its load carrying capacity to enable evacuation of the building

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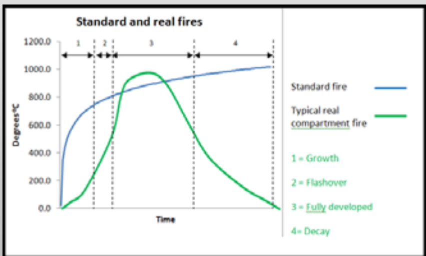
UK Fire Resistance (Risk Based)

Building Description+	Approved Document B (mins)	BS 9999 without sprinklers (mins)	BS 9999 with sprinklers (mins)
Open plan office building, 2 storey and less than 1000m² ground floor area.	30	15*	15*
Open plan office building over 30 metres but less than 60 metres in height.	120 plus sprinklers	90#	60
3 storey Department store.	60	45	30
Department store between 11 and 18 metres in height.	60	75	60
Medium risk, 4 storey storage.	90	90	60
Leisure centre, 2 storey	60	30	30

+ Height is measured from ground to the height of the floor of the top storey
* Most steel members can achieve 15 minutes fire resistance without added protection
# It is unlikely that planning permission would be given without sprinklers

Fire Resistance of Steel Structures



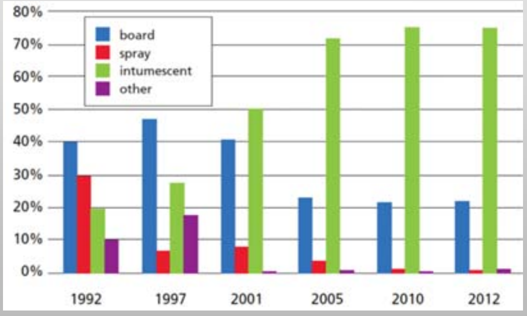
Fire resistance period is not the length of time that a structure will survive in a fire!

How Much Fire Protection

Designation		A/V ratio (m^{-1})			
Serial size		Profile 3 sides	Profile 4 sides	Box 3 sides	Box 4 sides
457 x 191	161	75	85	60	65

UKBs - 3 sided exposure - indicative data			
A/V	Critical temperature 620°C		
	Dry film thickness (mm) for fire resistance period		
	30 min	60 min	90 min
30	0.265	0.265	0.420
50	0.265	0.276	0.494
70	0.265	0.319	0.679
90	0.265	0.357	0.907
110	0.265	0.419	1.099
130	0.286	0.487	1.300
150	0.295	0.545	1.493
170	0.300	0.626	1.727

Trends in Fire Protection Materials



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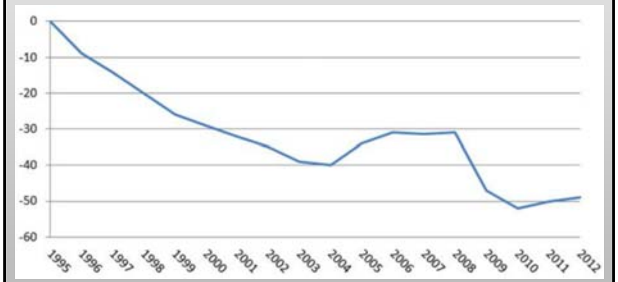
Change in Cost of Fire Protection



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Churchill Plaza, Basingstoke, UK

- 12 storey building
- Built in the 1988
- 90 minutes fire resistance; no sprinklers
- Severe 4 hour fire in 1991
- Fire destroyed 8th and 9th floors and damaged 10th floor

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Churchill Plaza – Fire Damage

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Fire Engineering Research 1994-97

8 storey test building

Bare steel composite beams and deck

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Fire Engineering Research 1994-97

Maximum fire temperature 1213°C
Beam temperature 1100°C
Standard isolated beam in fire test fails at 700°C

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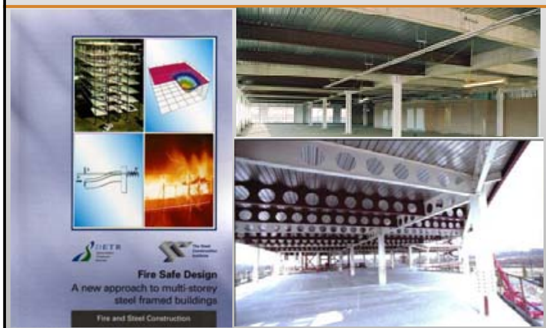
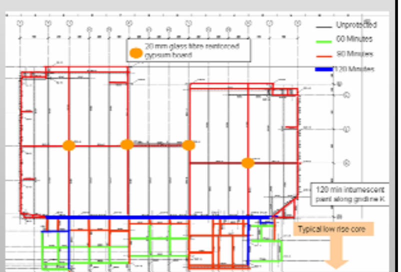
Plantation Place South (London) Fire Engineered Building

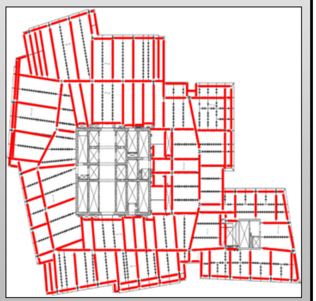
A Simplified Fire Engineering Approach (TSLAB)



Heron Tower, London (47 storeys)



The Shard, London (87 storeys)



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