Learning Objectives

At the end of this program, participants will be able to:

1. Through completed building case studies, participants will be able to see how engineered timber structures can compete directly with more traditional steel and concrete frame solutions.

2. Participants will be informed of the latest international and UK emerging regulation surrounding environmental profiling of construction materials and projects.

3. The issues associated with fire engineering of exposed timber structures will be presented (including fire rating and spread of flame).

4. Examples of innovative composite concrete floor and timber frame will be presented and outcomes of research testing will be shared.

Questions related to specific materials, methods, and services will be addressed at the conclusion of the presentation.

“The best friend of man is the tree. When we use the tree respectfully and economically, we have one of the greatest resources on the earth.”

Frank Lloyd Wright
RESOURCES
...UK construction

- £100bn construction output
  - Approximately 10% of UK economy
  - Approximately £40bn construction products
  - £100bn – 20million m² buildings?

- 400mt of construction materials annually
  - 1mt steelwork – 10million m² buildings?
  - 24mt concrete – 15million m² buildings?
  - 18m³ timber – 35million m² buildings?

Could the UK change to a timber intensive construction industry?

...Austria’s forest increasing at a rate of 10m³ annually which could provide structural timber for 30m² of new buildings.

According to the Building Research Establishment, building production in the UK accounts for about 8% of all carbon dioxide emissions, while the energy used in running buildings is responsible for 50%; in 1990 this amounted to 579 million tonnes.

UK FORESTRY COMMISSION REPORT
...comprehensive review

- UK Forestry Commission report
  - UK woodland could provide 10% CHG abatement (Scotland already 12%).
  - UK ‘forest carbon sink’ reducing from 16mt CO₂ in 2004 to 5mt CO₂ in 2020.
  - Wood fuel potential to save 7mt CO₂ in UK.
  - Wood substitution potential to save 4mt CO₂ in UK.
  - Estimated 70mt CO₂ stored in timber housing in UK.

UK FORESTRY COMMISSION REPORT
...science

- Wood is about 50% carbon (by dry mass)
- x 3.67 to convert C to CO₂
- Broadleaf forests 100-250 tC per ha
- Conifer plantations 70-90 tC per ha
- Carbon uptake 4 tC per ha per year in fast growing stands

Figure 3
Our energy system in 2050 could look substantially different

Combined heat and power plant
Low carbon businesses
Nuclear Power
Wind power

- Efficiencies: with carbon capture and storage

- Car: fuelled by electricity/ hydrogen
- Hybrid/hydrogen
- Electric charging

- More railways
- Sustainable agriculture
Building codes and other government policies that, where appropriate, can promote substitution of use of sustainably harvested forest products wood for more energy-intensive construction materials may have substantial potential to reduce net emissions (Murphy, 2004). Private companies and

Wood products can displace more fossil-fuel intensive construction materials such as concrete, steel, aluminium, and glass, which can result in significant emission reductions (Prinsen and Solberg, 2002). Results from Sweden and Finland suggests that constructing apartment buildings with

UK RESPONSE
...many facetted and complex

- Gradual increase in building regulations
- Zero carbon new buildings by 2019
- Existing building stock approach uncertain
- IGT report on low carbon construction
  - Issued November 2010
  - Treasury ‘Green Book’ requirement to conduct whole life carbon appraisal.
  - Industry and Government to develop a standard method of measuring embodied carbon for use as a design decision tool.
The Institute of Civil Engineers (ICE) Civil Engineering Standard Method of Measurement 3 (CESMM3) now includes carbon and prices for every material and unit of work.

The Royal Institution of Chartered Surveyors (RICS) has established a working group to examine embodied carbon and to also link it to the New Rules of Measurement (NRM) framework.

The European CEN TC 350 series of standards (spring-2011 release) relates to the “sustainability of construction works”. The series includes a set method for calculating the embodied impacts of construction materials and projects and a standard on the communication of results (Environmental Product Declarations, EPDs).

Industry claims:
- Steel (SCI) 762 kgCO2/t
- RC (Concrete Centre) 115 kgCO2/t
- Timber (Wood for Good) -900 kgCO2/t

Edinburgh Centre for Carbon Management
- Steel 2300 kgCO2/t
- RC 250 kgCO2/t
- Timber -1000 kgCO2/t

Bath University ICE
- Steel 1440 kgCO2/t
- RC 210 kgCO2/t
- Timber 390 kgCO2/t
**LIFE CYCLE ASSESSMENT**

...embodied CO2 and structural performance

- Timber beam 15kg CO2
- Concrete beam 50kg CO2
- Steel beam 60kg CO2
- But...60kg CO2 stored in timber beam

**SCOTTISH FORESTRY COMMISSION REPORT**

...timber construction

![Graph showing embodied CO2 in different structural components](image)

- Timber CLT frame
- Concrete flat slab frame
- Steel frame and hollow concrete floor

**SUMMARY**

...embodied CO2

- Current studies
  - Offices 750-1000 kg CO2/m²
  - Residential 300-675 kg CO2/m²
  - Schools 300-600 kg CO2/m²
- Typically 50% of a new buildings embodied CO2 is in the structure and foundations.
- Recent studies indicate that embodied CO2 can represent between 20% to 60% of the whole life CO2 of a building.

**CASE STUDIES**

...reducing embodied CO2

![Images of case studies](images)
CASE STUDIES
...a systematic approach

- Lean design
- Re-cycled materials
- Renewable materials
- Minimise waste
- Design for long life
- Holistic design

CASE STUDIES
...systematic approach

- Lean design
- Re-cycled materials
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MOSSBOURNE ACADEMY

- Exposed timber frame
  - £22.5m new build secondary school
  - 960m³ timber, 800t CO2 saved/stored
  - Equivalent to 10% renewables for 20 years?
Timber concrete composite floors

Direct competition to steel frame?

3x stiffer and 2x stronger
Exposed timber frame
- £10m new build faculty of education
- 240m³ timber, 200t CO₂ saved/stored
- Equivalent to 6% renewables for 20 years?
CASE STUDIES
...systematic approach

- Lean design
- Recycled materials
- Renewable materials
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CAMBRIDGE UNIVERSITY

- Physics for Medicine
  - Exposed concrete frame teaching and labs
  - 'Low Carbon' concrete mix
  - Equivalent to 3% renewables over 20 years?

NORWICH ACADEMY

- UK's largest timber frame
  - £22m new build secondary school
  - 3500m3 timber, 2900t CO2 saved/stored
  - Equivalent to 30% renewables for 20 years?
ST JOHN FISHER SCHOOL

- Solid timber panel construction
  - £11m extension and refurbishment
  - 1000m³ timber, 800t CO₂ saved/stored
  - Equivalent to 30% renewables for 20 years?
Peterborough School
- 975m² Sportshall and Studio
- Timber LCA -40tCO₂
- Steel LCA 220tCO₂
- Embodied CO₂ of structure only
CASE STUDIES
...systematic approach

- Lean design
- Re-cycled materials
- Renewable materials
- Minimise waste
- Design for long life
- Holistic design

SHEFFIELD UNIVERSITY

- Hybrid concrete system
  - £17m new build LRC using bubbledeck
  - 110,000 balls – 550m3 of RC saved or 175t CO2
  - Equivalent to 2% renewables for 20 years?
CASE STUDIES
...systematic approach

- Lean design
- Re-cycled materials
- Renewable materials
- Minimise waste
- Design for long life
- Holistic design

1 SOUTHAMPTON ROW

- Innovative cassette raft
  - 1500m³ concrete saved, 550tCO₂
- Long span steel structure 600t steel premium
- Concrete 550tCO₂ saving, steel 1150tCO₂ gain
CASE STUDIES
...systematic approach

- Lean design
- Re-cycled materials
- Renewable materials
- Minimise waste
- Design for long life
- Holistic design

BGS, NOTTINGHAM

- UK's first timber termodeck building
  - £5m new build offices
  - 450m³ timber, 365t CO2 saved/stored
  - Equivalent to 7% renewables for 20 years?
CASE STUDIES
...systematic approach

- Lean design
  - Post-tension concrete
  - Suitable floor spans
- Re-cycled materials
  - Cement replacement
- Renewable materials
  - Timber structures
- Minimise waste
  - Prefabrication
- Design for long life
  - Low maintenance, adaptable

Reduction in concrete and rebar
Approx 23% saving in ECO2
Approx 33 kg CO2/m²

Reduction in steel content
Approx 28% saving in ECO2
Approx 62 kg CO2/m²

Reduction in cement content
Approx 22% saving in ECO2
Approx 46 kg CO2/m²

Carbon negative?
Approx 32% saving in ECO2
Approx 52 (335) kg CO2/m²

In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the Course Evaluation link on the left side of the page.