A Life Cycle Approach to Sustainable Construction

Louis Brimacombe - Head, Environmental Technology
Setting the Scene … for Steel in Construction

- The markets for steel are increasingly sensitive to sustainability issues / low carbon market drivers including construction
- Steel has a positive contribution to make, but its sustainability image is weak
- Life cycle thinking helps to explain the role of steel in sustainable development and this will help set the foundation for positive messaging and raising awareness
- But we also need to drive product innovation and rethink our business models towards sustainability
- A forward strategy is important for future business success
Sustainability Trends in the UK Construction Sector

- UK Government policy is driving the sustainability agenda
  - 80% reduction in greenhouse gas emissions by 2050 (UK target)
  - ~50% of the UK's CO₂ emissions come from constructing and using buildings
  - UK has set ‘zero carbon’ targets for new buildings in 2016-19
    - Building regulations
    - BREEAM and Code for Sustainable Homes assessment schemes
      - Covers both material and in use environmental impacts

- Construction industry becoming aware of the **embodied** impacts of materials
  - Will become increasingly important as use phase emissions are reduced
  - More emphasis on **resource efficiency** and reducing waste
  - Materials as ‘enablers’ for sustainable buildings (part of the solution)
Setting the Scene…Rio +20 discussion topics

• Policy makers will push to accelerate low carbon / resource efficiency agenda
  • The number of middle class consumers will increase from 1 to 4 Bn in next 20 years
  • Demand/supply pressure for water, food, energy and materials will reach unprecedented and critical levels
  • WBCSD aspiration is for 9 bn people ‘living well’ by 2050, without compromise for future generations
  • Carbon reduction targets and mechanisms will continue to be debated (80% by 2050 is the benchmark)
  • Policies may set the framework but Business Leadership will drive implementation,

The challenge for steel and other materials is this:

Materials and energy demand are regarded as part of the problem, yet all pathways to 9bn people ‘living well’ will require excellence in materials developments, and a rethink about material and product life cycles.

To be part of the solution we need to embrace the problems that need to be solved…….
Meeting future demand would require historically unprecedented increases in supply.
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2050 Scenarios for Global Steel Manufacture

Global Steel CO₂ emissions

BAU 2050
ULCOS, higher recycling and operational efficiency
Reduce, Reuse/Remanufacture

….and focus on the product benefits

Post Kyoto aspiration 50-80% reduction

1 BtCO₂
1.2 Bt Steel

2 BtCO₂

2.4 Bt Steel

4 BtCO₂

2010

2050
Life Cycle Assessment: Carbon Emissions

Use phase dominates
vehicles/buildings/food packaging/motors/turbines

Raw material extraction
Material Production
Assembly & Distribution
Use
End of life

CO₂e
Competition between Materials using LCA

- Which material provides sustainable construction solutions?
  - Perceptions of steel as a sustainable material are poor in Europe
  - Increase in customers requests for information on environmental performance of materials, in particular LCA / carbon footprint

- How can we improve perceptions and explain that you are ‘part of the solution’?
- First step was to get LCA data for steel products…..globally…. with a common methodology
worldsteel Life Cycle Inventory (LCI) data

• worldsteel has been collecting LCI data since 1995.
• Approximately 30 companies worldwide participate
• Provides LCI data for 15 steel product groups.
• Robust methodology, ISO 14040/44 compliant, world class third party review,
• Tata Steel provided technical expertise from the beginning.

15 steel products
- Hot Rolled Coil
- Cold Rolled Coil
- Pickled Hot Rolled Coil
- Finished Cold Rolled Coil
- Tinplate
- Electrolytic Chromium Coated Steel (Tin-free steel)
- Sections
- Rebar
- UO Pipe
- Welded Pipe
- Organic Coated Steel
- Electro Galvanised
- Hot Dip Galvanized
- Plate
- Wire rod
Tata Steel : Life Cycle Data and Data Enquiries

Tata Steel site participation in data collection:

• Data collection at 4 Steelworks and 6 downstream sites

Tata Steel’s initial approach to manage data communications

• Promotion of data availability and methodology to Universities, consultants, customers, market sector bodies, government

• Data provision is not passive, it facilitates engagement and influence. Occasionally exposes poor methodology/data and practices

• Tailored response to data requests according to originator & enquiry. Invariably we engage to understand the methodology basis of the request

• Realisation that LCA was an important strategic tool and that steel lagged behind other materials in terms of positive promotion and awareness…
Alternative Materials Positioning in the Market

Why Choose Wood?

Apart from being an aesthetically pleasing material, wood is far easier and cheaper to work with than is often understood. By knowing the facts, you can make a more informed decision about whether wood is the right material for your project.

01 Wood has the best thermal insulation properties of any mainstream construction material.

02 Wood has the lowest embodied energy of any mainstream building material.

03 3 tonnes of CO₂ can be saved by using timber frame from the 20 tonne CO₂ footprint of a typical 3 bedroom detached house.

04 Wood from sustainably managed forests can actually be better than carbon neutral.
Tata Steel’s Journey to Excellence in LCA

- Robust Data and Methodology
- Market Sector Models and alternative materials
- Comms, Engagement and Influence
- Understand Methodology variants, engage in standards developments
- Customer support and strategic alignment, use in marketing & NPDs
- Expand to Sustainability assessments

Towards Excellence in LCA

Stakeholder engagement
### Development of Market Sector Models – work in progress

All our models follow ISO LCA Standards

<table>
<thead>
<tr>
<th>Model</th>
<th>Stages</th>
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<tbody>
<tr>
<td>Transport CF model</td>
<td>Raw Material Extraction – Material Production – Assembly &amp; Distribution – Use – End of Life</td>
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<tr>
<td>WorldAutoSteel auto CF model</td>
<td></td>
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<td>Packaging LCA model</td>
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<td>Sustainability Assessment Tool</td>
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Material Production

- Transport CF model
- WorldAutoSteel auto CF model
- worldsteel steel product LCI model
- Electrical Steels, tube, rail, leaded steels LCA models.
- Highways Parapet LCA model
- Colors Cladding LCA model
- CLEAR (Construction LCA model)
- Automotive LCA model
- Packaging LCA model
- Sustainability Assessment Tool
There is a growing requirement in construction to adopt the principles of sustainable development.

Inter-material competitiveness is a key issue.

Recognised the need to support customers with regard to the role of steel in sustainable buildings.

CLEAR was developed to allow Tata Steel to influence this debate.

CLEAR has been independently critically reviewed by Ove Arups in 2010.

The tool is unique in its range of capabilities.

The CLEAR tool has been used to support Tata Steel in the UK construction market:

• **Target Zero Project (www.targetzero.info)**
  The output of CLEAR contributed towards free industry guidance on how steel enables low and zero carbon buildings.

• **Cladding Environmental Product Declarations (EPDs)**
  A version of CLEAR has been used to produce EPDs for Tata Steel products and its customers.

• **“Design for Reuse” Feasibility Study**
  CLEAR was used to look at the environmental benefits of design for reuse

• **Recognition**
  2011 Tata Innovista European winners.
  Recognised at TSE CEO awards in 2011
Life Cycle Assessment: Carbon Emissions

Use phase dominates vehicles/buildings/food packaging/motors/turbines

CO$_2$e

Raw material extraction  Material Production  Assembly & Distribution  Use  End of life
Life Cycle Carbon Emissions
- As we approach zero carbon

Material CE become significant as we approach zero carbon

![Graph showing CO2e emissions for different stages of life cycle: Raw material extraction, Material Production, Assembly & Distribution, Use, End of life]
The Target Zero Project

To demonstrate that zero carbon buildings are achievable in steel and to deliver technical guidance for industry.

Five building types and three structural options for each

- Mixed Use
- Office
- Supermarket
- School
- Warehouse

www.targetzero.info
Life Cycle Carbon Emissions - Rise of absolute embodied carbon

Must not forget impact of zero carbon technologies and what happens to them at End-of-Life

<table>
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<tr>
<th>CO$_2$e</th>
<th>Raw material extraction</th>
<th>Material Production</th>
<th>Assembly &amp; Distribution</th>
<th>Use</th>
<th>End of life</th>
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Components of Embodied Carbon for zero carbon (use phase) buildings

- Foundations & Floor Slab
- Bearing Structure
- Upper Floor
- Walls
- Roof
- Drainage
- Site Works
- On-site Energy

Embodied CO$_2$e (tCO$_2$e)

- Base Case
- Option 1
- Option 2
Making use of LCA models

- Marketing products on environmental grounds
- EPDs produced for over 200 cladding systems
  - Both ours and our customers
**Reuse of Steel Sections**

### GWP v number of uses of structural steel before being recycled
for the Warehouse and Office Building

![Graph showing GWP v number of uses of structural steel before being recycled](image1)

### GWP for different reuse scenarios for the Warehouse and Office Building

![Graph showing GWP for different reuse scenarios](image2)

### GWP contribution from the building lifecycle stages for the Warehouse and Office Building

![Graph showing GWP contribution from the building lifecycle stages](image3)

### Resource use by material for the Warehouse and Office Building

![Graph showing resource use by material](image4)
Uses of CLEAR: The CLEAR iReport

Simplified front end

- Increase accessibility of LCA tool to non-experts

Tailored to the user needs:

- CLEAR – Over 300 user parameters!

Generate graphs, tables for their system – See the effect of their changes
Understanding Alternatives: Glulam (Glued laminated timber)

- Produced by laminating smaller pieces of timber into a large structural member by bonding with adhesives.
- Functionally equivalent to steel beams and columns.

<table>
<thead>
<tr>
<th>Span</th>
<th>92 kg/m</th>
<th>51 kg/m</th>
<th>130 kg/m</th>
<th>92 kg/m</th>
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<tbody>
<tr>
<td>16m</td>
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<td>18m</td>
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</table>
Lots of uncertainty at end-of-life for timber – is it really carbon neutral?
Do you know what will happen to the timber at end-of-life?
If timber is recycled does this imply new trees avoided so less CO₂ being sequestered?
Lots of uncertainty at end-of-life for timber – is it really carbon neutral?

Do you know what will happen to the timber at end-of-life?
Life Cycle Approach – End of Life Scenarios

**END-OF-LIFE SCENARIOS**

What happens to a building’s structural frame once it is demolished?

- **LANDFILL:** 58%
- **RECYCLED:** 13%
- **RE-USE:** 5%
- **DOWNCYCLE:** 20%
- **RECYCLED:** 13%
- **INCINERATION:** 6%

**CONCRETE**
The great majority of concrete is recovered from demolition and sources of raw material. The most sustainable option is to recycle it. The amount of aggregate that can be recycled is dependent on site and the type of concrete, where aggregate is recycled more often than not.

**TIMBER**
Deforestation information on what happens to timber within the industry. Following an extraction process, timber is sold for a variety of uses, including furniture, construction, and other products. The information presented here is from the UK’s Timber Guide.

**STEEL**
Steel is one of the most valuable and sustainable materials. It is recovered from demolition activities and recycled. The process is highly efficient, with steel being one of the few materials that can be recovered and reused multiple times.

Capture credits vary depending on the stage of extraction from the excavation to the final product. For steel, around 90% of the material can be recycled, providing significant environmental benefits.
Tata Steel’s Perspective on LCA and Steel Sustainability

- **LCA can be** an excellent decision support tool
- **We advocate** high quality data and methodological rigour to ensure that the decision support tool is robust
- Methodological choices can be controversial. It is important that the methodology is transparent/consistent and aligned to the goals of the LCA study
- One area of controversy is that end-of-life recycling is not always credited
- In our view the EOL recycling/reuse is a fundamental attribute of steel. Without including the EOL credit the LCA would be incomplete and material selection may be misinformed re future issues
- The issue across all materials is about driving behaviour towards sustainability and in this respect different materials need different behavioural drivers (plastic/timber drivers are not the same as steel)
End of Life Recycling or Recycled Content Methodology

Full LCA Approach

Material Consumption → End of Life Recycling

-ve (Burden) → +ve (Avoided Burden)

Recycled Content Approach

Recycled Content → End of Life Recycling

? +ve (Avoided Burden)

ISO 14040 series

Cut-off method

OR

Recycled Content → End of Life Recycling

Neutral (No Burden) → Neutral (No Burden)

What behaviour are you trying to drive?

What is good LCA?

For metals we believe end of life recycling should be included
Wellmet 2050 – from incremental to step change efficiency improvements for metal product life cycles

**Metals technology**

- **Use less metal:**
  - Integrate downstream; new processes with higher value added

**Material efficiency**

- **Re-use components:**
  - Reconditioned steel supply (c.f. cars)

- **Reduce yield losses:**
  - New processes and integration from liquid metal to component design

- **Divert scrap:**
  - Novel approaches to sheet blanking c.f. textiles

**Resource systems**

- **Longer life:**
  - Leasing and maintaining materials & components

- **More intensive use:**
  - Difficult – service models?
So what is Sustainability?

Now described in BS8905 Framework Standard

- **Economically viable**
- **Environmentally sound**
- **Enhanced Social Value**

…… with a life cycle approach and taking the longer term view!
Making the Sustainable Choice

Beyond environmental considerations, the functionality and economic performance of a material is crucial for making sustainable decisions. The social value aspects should not be underestimated!

Viability/Affordability/LCC

Carbon footprint
Resources use
Safety/comfort
Aesthetics
Future Challenges and Trends

- Stakeholder Engagement
- Establishing LCT into SATs (BS8905)
- Develop Social Value Metrics
  - Safety
  - Acceptance of qualitative values
    – Comfort/convenience
    – Aesthetics
- Economics
  - Internalising external costs
  - Life cycle costing
  - New business models
- Environmental
  - LCA methodology consensus
  - Water foot-printing etc

- Embodied carbon/cost will be more significant vs ‘use phase’ as we
  - Decarbonise the energy grid
  - Add more equipment (batteries/PVs)
- Resource Efficient materials
  - Reuse, use-less etc
  - Service provider/ Product ownership
- Availability of rare elements and substitution
- Local supply of resources/ localised recovery and recycling strategies (scrap)
“The steel industry believes that sustainable development must meet the needs of the present without compromising the ability of future generations to meet their own needs.”

“Steel is essential to the technologies and solutions that meet society’s everyday needs – now and in the future.”
Thank you