The sustainable efficacy of design approaches to the delivery of truly sustainable buildings
Sustainable buildings

- Healthy
- Productive
- Safe
- Enjoyable
- Low energy
- Low carbon
Sustainable buildings

- Reduce operating costs
- Increase productivity
- Enhance commercial values
- Create sustainable communities
## Sustainable buildings

<table>
<thead>
<tr>
<th>Certification</th>
<th>Year</th>
<th>Region</th>
<th>Version</th>
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</thead>
<tbody>
<tr>
<td>BREEAM</td>
<td>1990</td>
<td>UK and Europe</td>
<td>BREEAM UK New Construction 2014</td>
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<tr>
<td>Green Star</td>
<td>2003</td>
<td>Australia, New Zealand, South Africa</td>
<td>Green Star 2014 (July 2013)</td>
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<td>HK-BEAM</td>
<td>1996</td>
<td>Hong Kong</td>
<td>BEAM Plus V1.2 (2012)</td>
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<td>CASBEE</td>
<td>2001</td>
<td>Japan</td>
<td>CASBEE for New Construction 2010</td>
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## BREEAM Awards

<table>
<thead>
<tr>
<th>Category</th>
<th>Score Range</th>
<th>Rating</th>
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<tbody>
<tr>
<td>Outstanding</td>
<td>≥ 85%</td>
<td>⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>Excellent</td>
<td>≥ 70%</td>
<td>⭐⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>Very Good</td>
<td>≥ 55%</td>
<td>⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>Good</td>
<td>≥ 45%</td>
<td>⭐⭐⭐⭐⭐⭐</td>
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<tr>
<td>Pass</td>
<td>≥ 30%</td>
<td>⭐⭐⭐⭐⭐⭐</td>
</tr>
<tr>
<td>Unclassified</td>
<td>&lt; 30%</td>
<td>⭐⭐⭐⭐⭐⭐</td>
</tr>
</tbody>
</table>
BREEAM % Weighting

Construction Waste
Water
Innovation
Land Use & Ecology
Transport
Materials
Pollution
Health & Wellbeing
Management
Energy
BREEAM % Energy Weighting

- Energy Efficient Equipment
- Energy Efficient Laboratory
- Energy Efficient Transportation
- Energy Efficient Cold Storage
- Low and Zero Carbon Technology
- External lighting
- Energy Monitoring
- Reduction of CO2 emissions
Embodied Energy

End of Life Energy

Operational Energy

Embodied Energy (Up to 46% of Life Cycle Energy *)

* Dixit & Fernandez-Solis, 2012
Zero Carbon Buildings

- Embodied Carbon of Materials and Construction
- Operational Carbon Emissions
- End of Life Carbon Emissions

Progress towards Zero Carbon Buildings
Zero Carbon Buildings

Change of focus…more recycling …reuse….better technology….research

Embodied Carbon of Materials and Construction
Operational Carbon Emissions
End of Life Carbon Emissions
The Sir Charles Lyell Centre

Research Centre for Earth and Marine Science and Technology

- Constructed to BREEAM “Very Good”
- Delivered using BSRIA Soft Landings
- Delivered using BIM Level 2
## Case Study Building: construction

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>External Walls</strong></td>
<td>steel framing system with clay facing brickwork</td>
</tr>
<tr>
<td><strong>Windows</strong></td>
<td>Curtain walling system</td>
</tr>
<tr>
<td><strong>Upper floor</strong></td>
<td>Steel frame with in situ concrete floor slabs on metal decking</td>
</tr>
</tbody>
</table>
Materials (Mat01, Mat03, Mat04)

Step 1
Calculate scoring for materials spec using BRE Green Guide Ratings

Step 2
Calculate points uplift using CO$_2$ emissions data

Step 3
Calculate building element score

Translated into points

Translated into Tier Max points

TOTAL
Materials Weighting

- Floor finishes/covering: B
- Upper floor slab: A+
- Windows: D
- Roof: B
- Internal Walls: A+
- External Walls: A+
Energy (Ene01)

The Energy Performance Ratio (EPRNC) is derived from the building floor area, notional and actual building energy demand and consumption, Target Emission Rate (TER) and Building Emission Rate (BER).

Dynamic thermal simulation software was used to estimate the operational energy demand and emission rating for the building.

EPRNC = 0.6  10 / 15 Credits
Transport (Tra01)

Accessibility of public transport

- Walk time
- Average wait time
- Total access time

Accessibility Index (AI)

1 / 2 Credits
Water (Wat01)

- $T_{n_{\text{Act}}}$: Modelled Net Water Consumption
- $T_{n_{\text{Base}}}$: Modelled Baseline Water Consumption
- $T_{n_{\text{Occ}}}$: Total Default Occupancy Rate

% Improvement
## Water (Wat01)

<table>
<thead>
<tr>
<th></th>
<th>$T_{1,\text{Act}}$ (L/pers/day)</th>
<th>$T_{2,\text{Base}}$ (L/pers/day)</th>
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</thead>
<tbody>
<tr>
<td>WCs</td>
<td>17.7</td>
<td>26.5</td>
</tr>
<tr>
<td>Wash hand basin taps</td>
<td>8.7</td>
<td>20.5</td>
</tr>
<tr>
<td>Kitchen taps</td>
<td>13.6</td>
<td>14.9</td>
</tr>
<tr>
<td>Showers</td>
<td>33.6</td>
<td>78.4</td>
</tr>
<tr>
<td>Commercial dishwashers</td>
<td>18</td>
<td>28</td>
</tr>
</tbody>
</table>

**Improvement** = 45.6%

**3 / 5 Credits**
Waste (Wst01, Wst02)

According to the general structural clauses for the Lyell Centre, the contractor shall provide evidence of the site waste management scheme and keep coordinating and cooperating with sub-contractors of the plan.

There is no applicable pre-demolition audit for this project. At the same time, the target total percentage of recycled/secondary high-grade aggregate is not available.

Wst01 and Wst02 cannot achieve any credits at this stage.
Land Use & Ecology (LE03, LE04)

- **Plant diversity**
  - An indicator for evaluating the project’s impact

- **Ecological Value**
  - Calculated for the previous and post-construction site

- **Final Ecological Impact**
  - Measures change in area and land richness over parking land, mixed woodland, hedge land and grassland

Impact is -1.89. Although negative, it is not less than -9.

LE03 1 / 2 Credits

LE04 0 Credits
Pollution (PO01, PO02)

Based on refrigerant used in the chilled water system

\[ \text{GWP}_{\text{R410A}} = 1725 \text{ kg CO}_2\text{e} \]

- **PO01** 2 / 3 Credits

Based on \(\text{NO}_x\) emission from heating and hot water systems

-空间供暖 \(\text{NO}_x\) 排放：\(X_{\text{CHP}} = -1123 \text{ mg/kWh}\)
-热水供暖 \(\text{NO}_x\) 排放：\(X_{\text{LTHW}} = -761 \text{ mg/kWh}\)

- **PO02** 3 / 3 Credits
# BREEAM Pre-assessment summary

<table>
<thead>
<tr>
<th>Environmental Section</th>
<th>Credits Available</th>
<th>Credits Achieved</th>
<th>Section Weighting (%)</th>
<th>Section Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>22</td>
<td>22</td>
<td>12</td>
<td>12</td>
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<tr>
<td>Pollution</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>9.23</td>
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<tr>
<td>Materials</td>
<td>13</td>
<td>11</td>
<td>12.5</td>
<td>10.58</td>
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<tr>
<td>Water</td>
<td>9</td>
<td>7</td>
<td>6</td>
<td>4.67</td>
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<tr>
<td>Health &amp; Wellbeing</td>
<td>17</td>
<td>13</td>
<td>15</td>
<td>11.47</td>
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<tr>
<td>Energy</td>
<td>32</td>
<td>23</td>
<td>19</td>
<td>11.88</td>
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<tr>
<td>Transport</td>
<td>11</td>
<td>5</td>
<td>8</td>
<td>3.64</td>
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<tr>
<td>Waste</td>
<td>6</td>
<td>1</td>
<td>7.5</td>
<td>1.25</td>
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<tr>
<td>Land Use &amp; Ecology</td>
<td>10</td>
<td>1</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Innovation</td>
<td>10</td>
<td>2</td>
<td>10</td>
<td>2</td>
</tr>
</tbody>
</table>

**Total BREEAM Score**: 67.71  
**Rating**: "Very Good"
Soft Landings

- building form and orientation
- early design decisions
- energy performance
Soft Landings

- design team
- knowledge
- integration and communication
- services, fabric, and product design
- dependence on technology
- complicated systems
Soft Landings

- Concept Design
- Detailed Design
- Procurement
- Construction & Handover
- Testing
- Modelling Tools

- Detailed manufacturing data
- Skills and competency gap
- Product substitution without consultation
- Out of date tender documentation
Soft Landings

- collaboration and information exchange
- poor installation
- poor site management
- poor craftsmanship
- improvisations
- insufficient pre-handover commissioning
Soft Landings

- limited in-situ testing
- methodology consistency
- lack of dynamic building qualities in testing e.g. solar gains
Soft Landings

- commercial pressures
- accuracy concerns
- lack of transparency
- concern over assessor competency
- concerns over robustness and overheating checks
Building Information Modelling

- Cost savings
- Clash detection
- Schedule and time savings
- Reduced waste
- Environmental benefits
- Improved design
Conclusions

• Do sustainability rating systems for buildings actually produce low energy, low carbon buildings in practice?

• Does the simultaneous use of BREEAM, SL and BIM lead to the optimal building design and operation for its occupants? Is this excessive? Is this sufficient? Is there a better way?

• What is the impact on lifecycle carbon and energy of using responsibly sourced materials; using locally sourced labour and expertise; performing enhanced POE; and designing for recyclability?
Thank you

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