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# EDUCATING CIVIL ENGINEERS FOR SUSTAINABLE CONSTRUCTION

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## OUTLINE

Sustainability

Formation of Civil Engineers
- Accreditation of Degree Programmes

Embedding Sustainability
- Challenges
- Sustainability in educational programmes

Conclusion



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## SUSTAINABLE DEVELOPMENT

Our Common Future (Report 1987):

"A development that meets the needs of the present without compromising the ability of future generations to meet their own needs."




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## SUSTAINABLE DEVELOPMENT

Possible actions:

Reduce energy consumption in materials procurement and construction processes.

Use renewable energy sources wherever possible.

*Et cetera*



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## FORMATION OF CIVIL ENGINEERS

"Formation" of engineers includes an educational base at a university supplemented by practical experience.

In many countries, a long five year degree prepares students for full status as practising engineers.

Registration as a Chartered Engineer is usually required.



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## FORMATION OF CIVIL ENGINEERS

In the UK and a few other countries, "Formation" involves separate periods of education and training.

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## FORMATION OF CIVIL ENGINEERS

The educational base is formed in a university, while the training is received in employment.

After a suitable period beyond graduation, typically three years, the candidate takes a "professional examination" to become a "Chartered Engineer".



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## EDUCATIONAL BASE

In the UK, the standard educational requirement for becoming a Chartered Engineer is a 4-Year MEng.

Alternatively, a 3 Year BEng programme followed by a One-Year MSc is acceptable.

Only accredited programmes are recognised for the educational base.



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## ACCREDITATION

Accreditation of university programmes in engineering is now prevalent in many countries of the world.

UK has a long standing system whereby professional institutions undertake the task of accrediting educational programmes.

ice The Institution of Structural Engineers



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## ACCREDITATION

Civil Engineering programmes are accredited by a Joint Board of Moderators (JBM), representing the Institution of Civil Engineers, the Institution of Structural Engineers and two other transport related institutions.

The membership of JBM is drawn equally from academic institutions and industry.

JBM



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## ACCREDITATION

The process of accreditation involves, apart from substantial amount of paperwork, a visit by a team from the JBM.

Apart from the core subjects of Structures, Geotechnics, and Materials, plus two other topics such as Hydraulics and Transportation or Construction Management, one of the aspects that JBM emphasises is the embedding of Sustainability in degree programmes.



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## SUSTAINABLE DEVELOPMENT - EXAMPLE

London 2012 Olympic Park

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## LONDON 2012 OLYMPIC PARK

**Sustainable Design Objectives:**

- **Minimise Carbon Emissions**
- **Water : Efficient use**
- **Waste: Reduction through Design**




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## LONDON 2012 OLYMPIC PARK

**Sustainable Design Objectives:**

- **Use Environmentally responsible Materials**
- **Biodiversity of region (Lea Valley)**




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## LONDON 2012 OLYMPIC PARK

**Sustainable Design Objectives:**

- **Support communities: Safe mixed use public space**
- **Prioritise Walking, Cycling and Public Transport**
- **Plus others**



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## SUSTAINABILITY CHALLENGES

**Complexity of the Construction Process**

**Values-based Decision-making**

**Inter-disciplinarity of Construction**



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## COMPLEXITY

**Designers have to face difficulties, because:**

- **Clients do not always define the problem fully**
- **It is difficult to bring all the factors together**
- **What is important in one location may be unimportant in the next**




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## VALUES-BASED DECISION-MAKING

**Unlike optimising a structure for weight, in a major project, there may not be single correct answer.**

**Among several 'right' answers which is the right answer is subjective.**

**Engineers need to become comfortable with applying judgment to subjective decision-making.**

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## INTER-DISCIPLINARITY OF CONSTRUCTION

**Process of Sustainable Design requires collaboration with professionals from a wide-range of disciplines.**

**Engineers need to become comfortable with inter-disciplinary working.**



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## SUSTAINABILITY IN EDUCATIONAL PROGRAMMES

**Introducing a subject with the title 'Sustainability' or 'Sustainable Design' is not the solution.**

**Knowledge and skills required for sustainable design need to be spread throughout the programme modules.**



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## SUSTAINABILITY BUILDING BLOCKS

**Definitions of sustainability**

**Concepts of Life-Cycle assessment**

**Impact of sustainability on civil engineering**

**Tools for environmental assessment**

**Environmental management systems**



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## LIFE CYCLE COST ANALYSIS

**National Institute of Building Science (USA)**

**The web-site has very useful information on Life-Cycle Cost Analysis, suitable for students and experts alike.**

**http://www.wbdg.org/resources/lcca.php**



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## LIFE-CYCLE COST ANALYSIS

**Using a real number, even if crudely estimated, can help a student understand the concepts of embodied energy and life-cycle assessment.**

**A helpful web-site where approximate numbers are available is:**

**http://expeditionworkshed.org/workshed/the-engineers-toolbox/**



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## APPROXIMATE COSTS

| Costs | | |
|---|---|---|
| Approx costs | Residential buildings | £ 1500/m² 50 storey<br>£ 1000/m² 3 storey |
| | Offices | £ 1800/m² 50 storey<br>£ 1100/m² 3 storey |
| | Factories | £ 400/m² single storey |
| | Structural steel | £ 1000 per tonne (simple frames) |
| | Reinforced concrete | £ 150/m³ (simple)<br>£ 250/m³ (complex) |
| | Timber | £ 1000/m³ |
| | Structural earth fill | £ 15 to 20/m³<br>£ 12/m3 to dig and re-use clean fill from site<br>£ 40/m³ to dig and dump clean fill from site<br>£ 50 to 100/m³ to remove contaminated material from site |
| | Facades | £ 150/m² (brick) to £1000/m² curtain wall triple glazed |

THE ENGINEER'S TOOLBOX

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## PRACTICAL STEPS

**Encourage students to map the system for building design, so as to appreciate interactions between different stakeholders.**

**Ask students to appraise building options in the context of sustainability.**



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## PRACTICAL STEPS

**Consider inter-departmental design projects. A common example is to bring students of Architecture and Civil Engineering together.**

**Similarly, combining groups of students from Mechanical Engineering and Civil Engineering could help better understanding of the interaction between the building structure and building services.**



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## PRACTICAL STEPS

**Emphasise a commitment to prfessional values: honesty, care, fairness, respect, commitment to health and safety, and a commitment to sustainable development.**

**Take students outside their 'comfort zone'. Discuss ethics. Challenge students to consider the harm that engineers have caused in the past.**




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## CONCLUSION

**The Joint Board of Moderators in the UK require degree programmes to embed sustainability in the curriculum.**

**Guidance has been provided to help teachers in achieving this goal.**



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## ACKNOWLEDGEMENTS

**Joint Board of Moderators sponsored publication: "Embedding sustainability in undergraduate civil engineering courses"** Published by Think Up. **This publication has many further references**

**Also, numerous web-sites for the clip-art and images used.**



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## THANK YOU FOR YOUR ATTENTION