ENGR19000
Elementary Engineering Design

Mechanical and Civil Engineering (MCE)

Bridge construction

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Materials for Bridge Construction

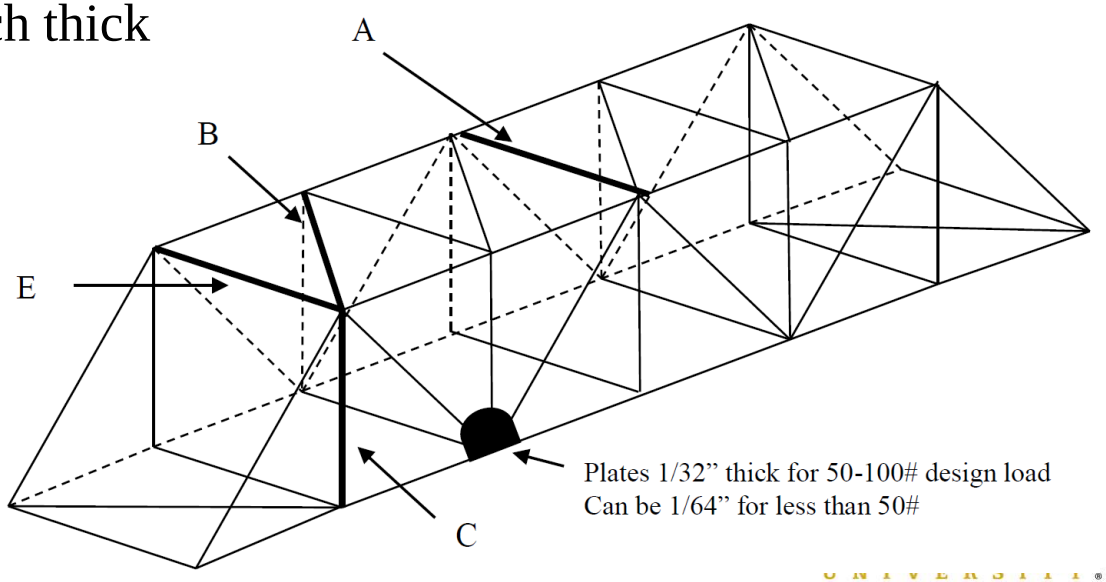
Bridge Members Materials

- Basswood
- Sizes – **3/32, 1/8, 5/32, 3/16, 1/4** inch on a side

Plates Materials

- Plates are used to reinforce joints
- Material –plywood
- Sizes – 1/32 & 1/64 inch thick

- Plates are ***1/32"*** thick for 50-100lbf design load;
- Plates can be ***1/64"*** for less than 50lbf design load

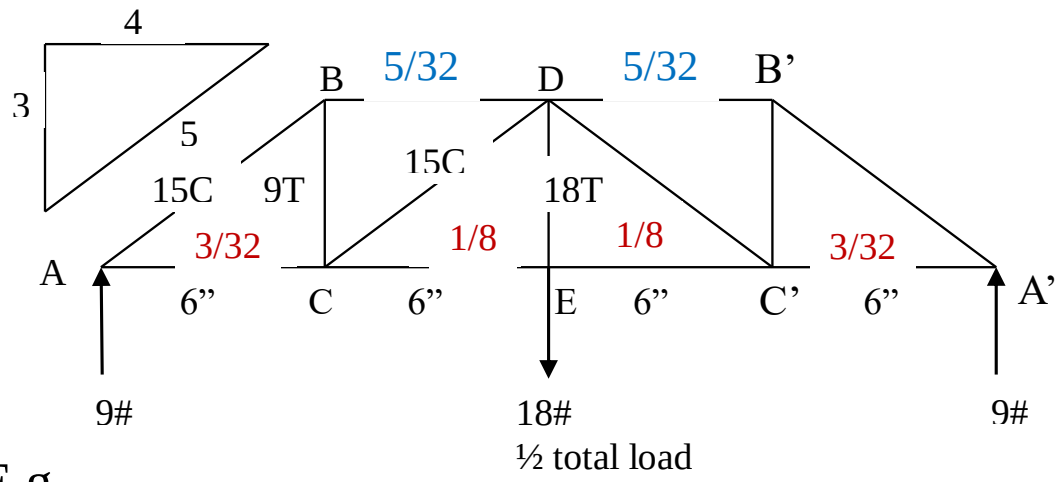


Tools for Bridge Construction

- Essential tools
  - Miter box, saw, glue
- Helpful tools
  - Sand paper, hand files, and accelerator (reduce curing time), knives, wood clamps

Reminder

- Through the your bridge design, different members use different sizes. However when you construct your bridge, do not use short pieces end to end for top and bottom chords. Always use one single piece for top and bottom chords.



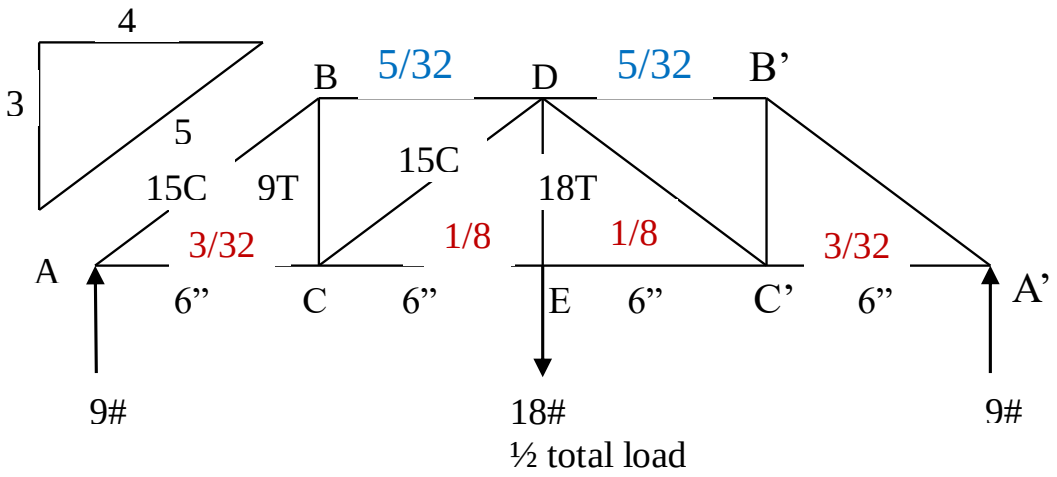
Member	Size
AB	3/16
BC	3/32
AC	3/32
BD	5/32
CE	1/8
DE	3/32
CD	3/16

E.g.

- Use one single piece (12") of 5/32 basswood for top chord.
  - ✓ DO NOT use two pieces of 6" 5/32 basswood
- Use one single piece (24") of 1/8 basswood for bottom chord.

✓ DO NOT use one 6" 3/32 + one 6" 1/8 + one 6" 1/8 + one 6" 3/32.

✓ Use 1/8 basswood, not 3/32.→1/8 is thicker and stronger than 3/32, so it can sustain the forces in both AC, A'C' and CE, C'E.



Member	Size
AB	3/16 √
BC	3/32 √
AC	3/32
BD	5/32
CE	1/8
DE	3/32 √
CD	3/16 √

E.g.

1. Keep using the sizes you calculated for other truss members (AB, BC, CD, DE, DC', B'C', A'B') and cross members.
2. Use one single piece (12") of 5/32 basswood for top chord.
3. Use one single piece (24") of 1/8 basswood for bottom chord.

This tip is to avoid the risk caused by 'non-professional' gluing of joints.

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- After applying the above construction tip, your bridge weight may be increased a little bit, but at same time, your bridge can hold more load and the weight of glue and some joint plates can be saved.

$$PV = \frac{Load\ (lbf)}{Weight\ (g)}$$

- These effects will be balanced out eventually. It will not change your performance value much, so you don't need to go back to change your design.

Bridge Testing

Performance Value $PV = \frac{Load\ (lb)}{Weight\ (g)}$

L is the test load (lbf)

- Load will be increased until bridge is broken.
- The load at this breaking point will be recorded by machine.

W is the weight of the bridge (g)

- Measured by precision scale

PV will be recorded.

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Bridge Collapses

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Continuous improvement in Engineering

- Materials and Technology:
- More efficient designs (lighter, stronger, etc.)
- More efficient construction (faster, easier, more precise)
- **Sustainablility**

- Software:
- Design, modeling and calculation
- BIM methodology (Building Information Modeling)

Pick up your bridge kit at:

- Anderson 152

Sustainability

New World Grand Challenges

- **Education**
- **Food**
- **Health**
- **Poverty**
- **Security**
- **Water**
- **Energy**
- **Climate Change**

and more …

https://sustainabledevelopment.un.org/

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Climate Change

CO_2 in the atmosphere acts like the glass in a greenhouse – it traps in heat

Burning fossil fuels is the main sources of CO_2 emissions

More CO_2, more heat

- Sea level is rising
- Natural disasters becoming more frequent
- Weather patterns are changing
- Storm frequency and severity is increasing
- Polar ice caps are melting

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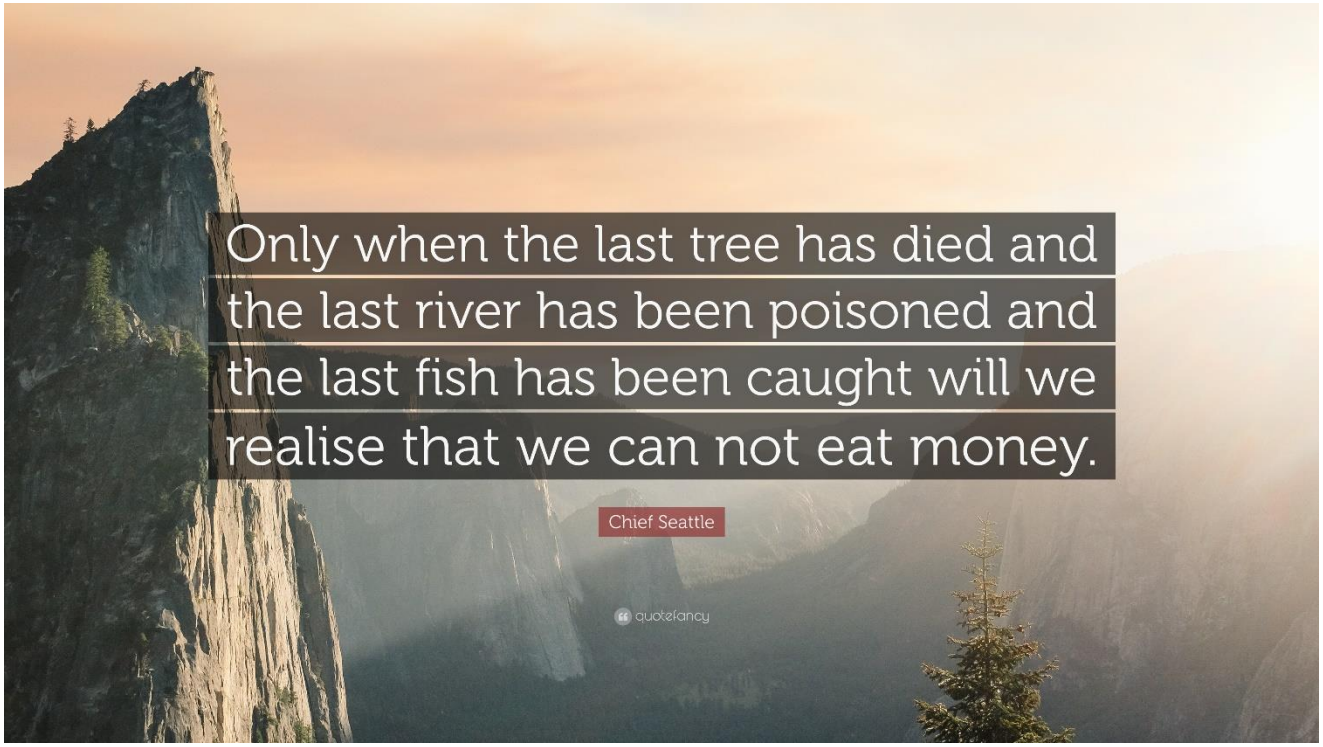
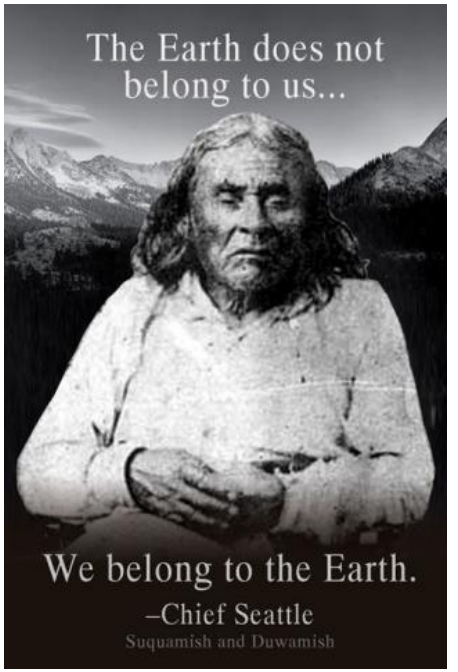
“As you walk upon the sacred earth, treat each step as a prayer”

"Every part of this soil is sacred in the estimation of my people…

How can you buy or sell the sky, the warmth of the land? The idea is strange to us. If we do not own the freshness of the air and the sparkle of the water, how can you buy them?

Black Elk





Sustainability

By “Sustainability” we mean the balance that allows Earth´s biosphere and human activities to continue to co-exist.

The common definition of sustainability in engineering fields is: **"meeting the needs of the present generation without compromising the ability of future generations to meet their needs"** (Brundtland, 1987).

Sustainability and Ancient people

Ancient people had a deep understanding of the environment and the interdependence of all living things. Here are some ways that ancient people practiced sustainability:

1. **Conservation of resources**: Ancient people conserved natural resources such as water, forests, and soils. They had a deep respect for nature and used resources carefully and sparingly.
2. **Crop rotation and terracing**: Ancient farmers practiced crop rotation to maintain soil fertility, prevent soil erosion and control pests. They also used terracing techniques to conserve water and prevent soil erosion in hilly and mountainous regions.
3. **Traditional knowledge and practices**: Ancient people relied on their traditional knowledge and practices to manage their environment sustainably. They had an intimate knowledge of the local ecosystem and used that knowledge to manage natural resources.
4. **Use of renewable resources**: Ancient people used renewable resources such as solar, wind, and hydropower for energy needs. They also used animal and human labor to accomplish tasks that today would be done by machines.
5. **Local production and consumption**: Ancient people produced and consumed goods locally, reducing transportation costs and carbon footprint. They also had a deep understanding of the seasonal availability of resources and adjusted their consumption accordingly.
6. **Respect for biodiversity**: Ancient people respected biodiversity and maintained a balance between human activities and the natural world. They recognized the importance of preserving species and habitats for the overall health of the ecosystem.

Sustainability/Green Engineering

It involves considering the long-term environmental, social, and economic impacts of engineering projects and striving to create designs and systems that are sustainable and resilient over time.

Economy
to optimise economic returns

Environment
to optimise the use of natural resources and minimise environmental impacts

Society
to supply human needs and improve quality of life

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Sustainability in Engineering

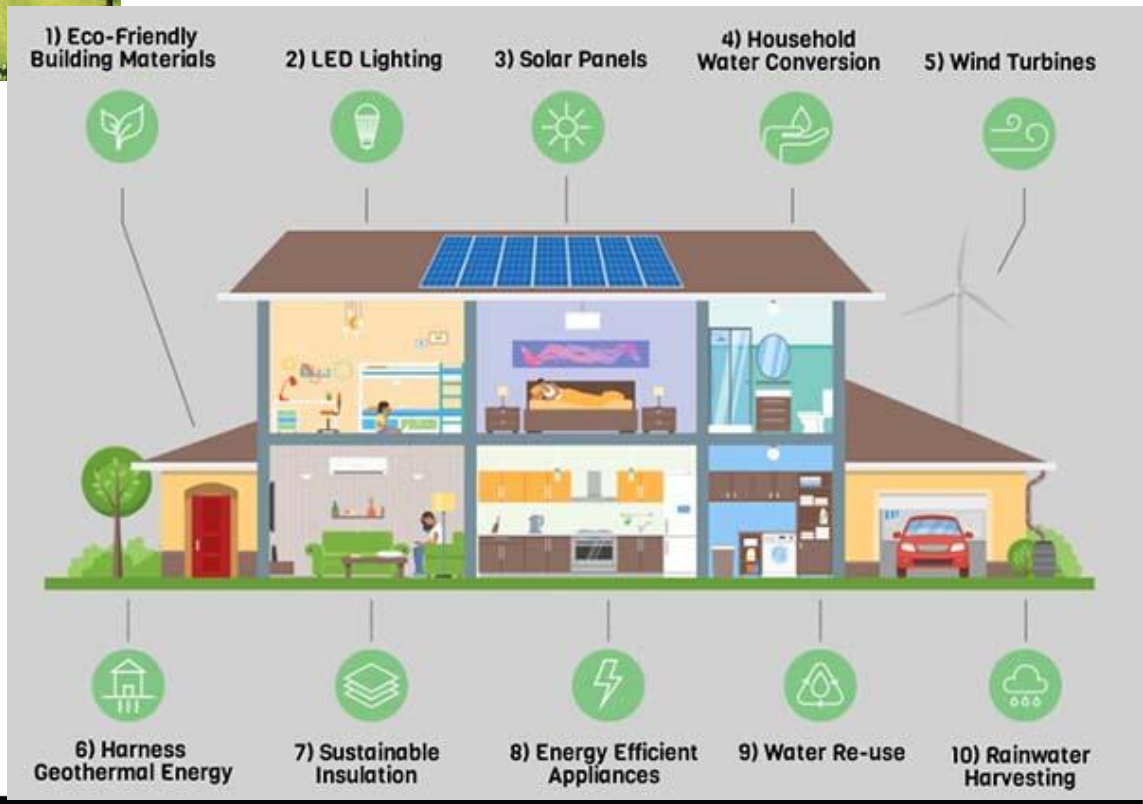
Sustainable engineering involves a holistic approach that considers the entire life cycle of an engineering project, from the extraction and processing of raw materials to the disposal or reuse of waste. This includes:

- Evaluating the environmental impact of materials and processes used in engineering projects
- Reducing energy consumption
- Minimizing waste and pollution
- Designing systems that are resilient and adaptable to changing environmental conditions.

Sustainability practices

A green roof, which helps to reduce heat island effects, improve air quality, and provide habitat for birds and insects

Civil engineers can design and build sustainable buildings that minimize the use of energy and natural resources. This can include using energy-efficient lighting and appliances, using environmentally friendly materials and designing structures to minimize waste.



Sustainability practices

A solar panel installation, which generates renewable energy and reduces reliance on fossil fuels

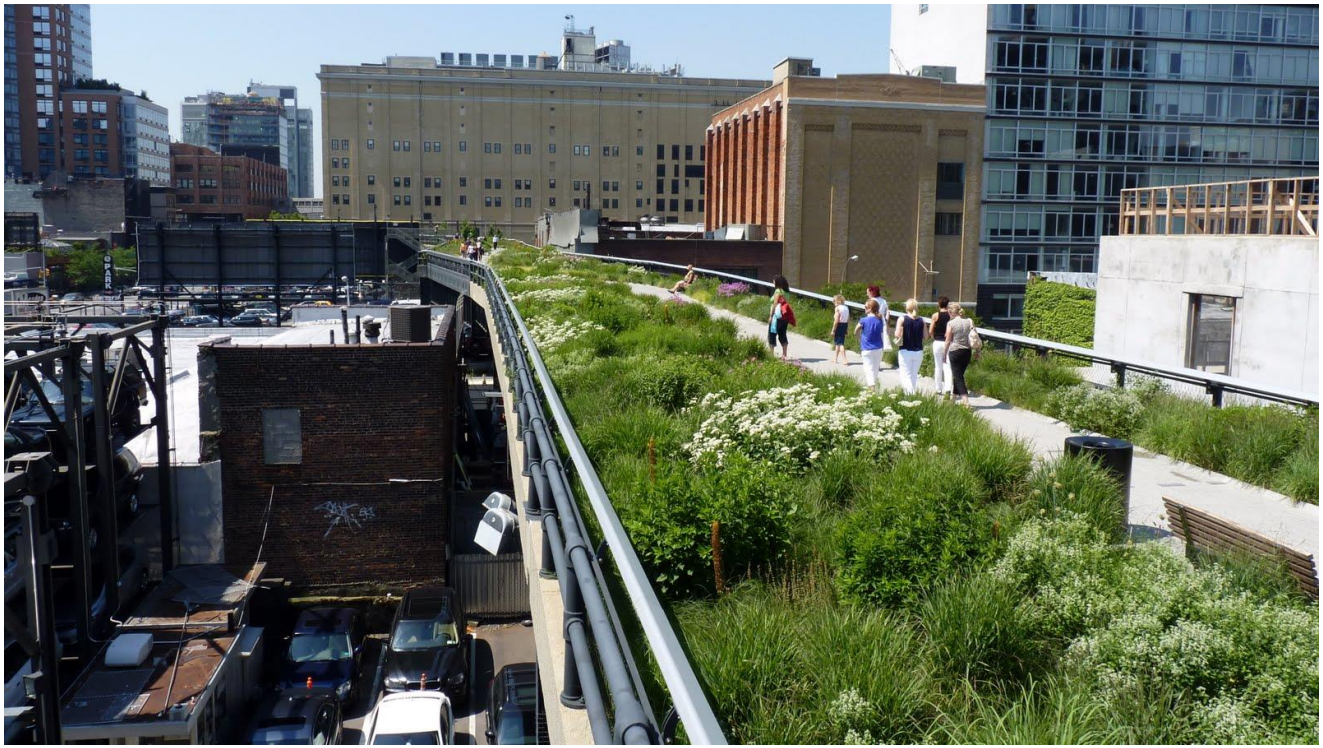
Wind turbines

The Bosco Verticale in Milan

- This building was designed by civil engineers to incorporate over 900 trees and 20,000 plants, which help to improve air quality and biodiversity in the city. The building also includes rainwater harvesting and solar panels, which reduce its environmental impact.

The High Line in New York City

This elevated park was built on a former railway track, showcasing how old infrastructure can be repurposed to create sustainable public spaces. The park includes drought-resistant plants, which reduces the amount of water needed for irrigation.



Sustainability practices

Sustainable transportation systems, which promote the use of low-carbon transportation modes like public transit, cycling, and walking. This can include the development of bike lanes and pedestrian-friendly infrastructure:

Sustainability practices

Additive manufacturing

- **Reducing material waste**
- **Light weighting**: This can lead to improved fuel efficiency in vehicles and reduced energy consumption in other applications.
- **Localized production**: With 3D printing, products can be manufactured on-site, which can reduce transportation emissions associated with shipping products from distant locations. This localized production can also provide economic benefits by reducing the costs associated with long-distance shipping.
- **Repair and maintenance**: Additive manufacturing can also be used to create replacement parts, reducing the need to replace entire products. This approach can prolong the lifespan of products and reduce waste.
- **Sustainable materials**: 3D printing materials can be made from recycled or sustainable materials, reducing the carbon footprint associated with manufacturing.

Green and Sustainable Design in engineering

- Green and Sustainable Design focuses on protecting the environment and the health of people and wildlife. A sustainable design analyzes the long-term impact on these things, along with the economic aspects.

Complete a short essay 'Green and Sustainable Design' by addressing the following questions:

• What are green, sustainable or recycled materials?

• Compare traditional materials with sustainable materials for engineering applications and discuss their impact in global, economic, environmental and societal contexts.

• Give an example of an engineering project and what other aspects besides materials should be considered for a sustainable design.

- What are some valuable insights we can gain from studying ancient sustainability practices

- 500-800 words/single line space/12pt/Times New Roman