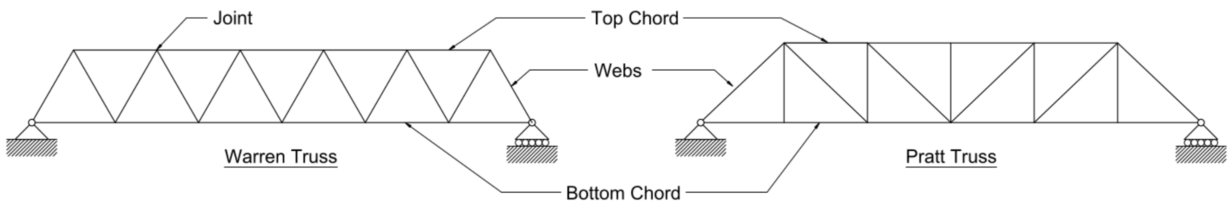
Lecture 12, Oct 11, 2021

Truss Bridges

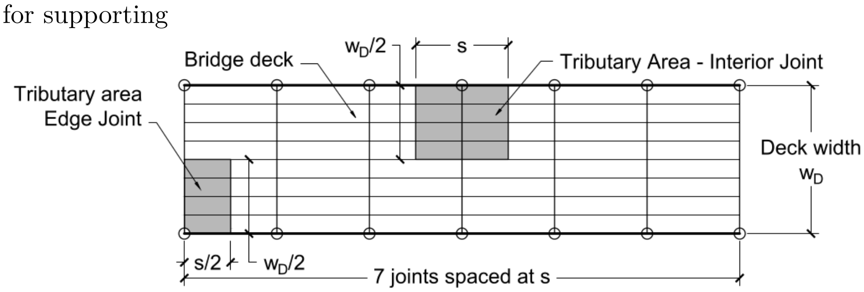
- Trusses are assemblies of steel or wood connected to form lattice-like structures
- Modern truss bridges are commonly built using steel (often hollow tubes) bolted or welded together
- The cross members at the top are called wind bracings and resist horizontal loads caused by winds etc
- Why use trusses?
  1. They're light since most of their volume is air (including hollow members)
  2. They're stiff – they deform very little under loads (the taller the truss, the stiffer it is)
  3. They're very efficient

Design Process for Truss Bridges



Note these are *elevation views* (views from the side); there are also *plan views* that look at it from above

1. Define the truss geometry: The span, height, deck width and configuration are determined
   - Increasing the height of the truss at the midspan reduces the forces in the top and bottom chords but increases cost
   - Also includes the number of vertical and diagonal members, which comes from experience
2. Estimate the joint loads: Estimate the point loads where the deck meets the structure
   - Assumptions:
     1. All connections are modelled as hinges/pins
     2. All loads are applied at joints
     - As a result of these assumptions, all members only carry axial loads (no bending)
   - The loads are often assumed to be uniform, unless designing for trains or very short bridges where every wheel matters
   - Load estimations:
     - The total load must take into account the weight of the deck, the self-weight of the truss structure, and live loads such as people
     - $w_{total} = w_{deck} + w_{struct} + w_{live}$
     - The live load is often taken as 5.0kPa, or 100lbs/ft^2
     - For wood decks w_{deck} can be estimated as 1.0kPa
     - w_{struct} is typically between 0.5 to 1.0kPa when using hollow steel members to span distances up to 100m
     - The joint load $P_i = w_{total} A_{trib}$ where A_{trib} is the joint's *tributary area*, the area it is responsible for supporting



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3. Solve for the reaction forces and analyze all member forces
4. Size the members so they can safely resist the loads (lecture 15)

5. Repeat steps 1-4 to design cross bracing
   - Cross bracing is added to resist horizontal loads caused by wind and instability effects (lectures 16-17)
6. Calculate the stiffness of the bridge by estimating the deflection at the midspan (lecture 18)
7. Design against dynamic loads: Testing for resonance (lecture 19)
8. Check if the initial estimate of structure weight is greater than the actual structure weight
   - Initially the bridge was designed with an estimate of w_{struct}, so now we need to make sure that estimate was reasonable
   - If the real weight is greater than w_{struct} the process must be repeated with a more conservative estimate
9. Detailed design
   - Everything before this is the preliminary design; the actual detailed process for the design is more complicated and not covered in first year

Analysis By Method of Sections (From Lecture 13)

- With the Method of Joints, calculating forces in the middle of the bridge is a tedious process; for preliminary designs and estimates the Method of Sections can be used to get them faster

- This method uses all 3 equilibrium equations to solve for up to 3 unknown member forces that pass through a section of the truss

- The truss is cut at some location and 2 free body diagrams are constructed:

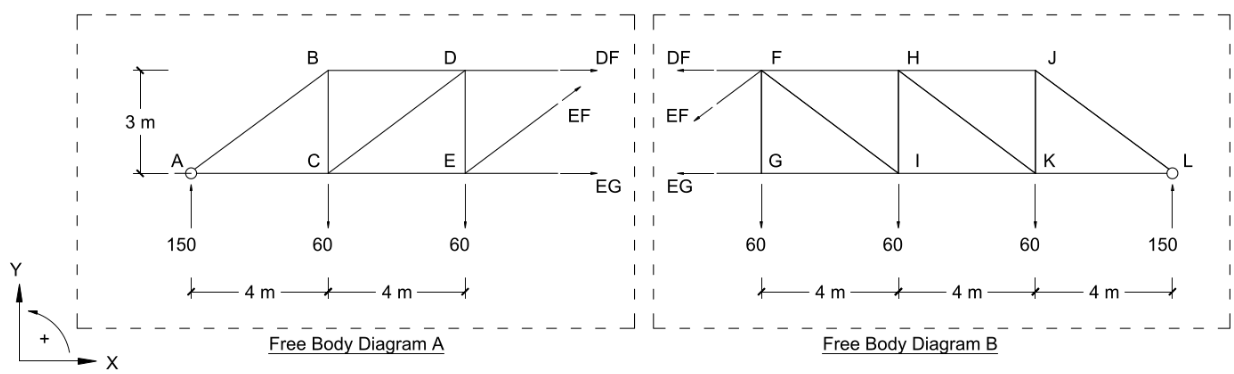

Figure 1: free body diagrams

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- In Diagram A, $\begin{cases} \sum F_x = 0 & \implies DF + EF_x + EG = 0 \\ \sum F_y = 0 & \implies 150 - 60 - 60 + EF_y = 0 \\ \sum M = 0 & \implies 60 \cdot 4 - 150 \cdot 8 - 3DF = 0 \end{cases}$
  - The equations of equilibrium should only include the support reaction forces, the joint loads, and the unknown internal forces we're trying to solve for
  - Note point E was taken for the moments, since this eliminates EF, EG and load at E, leaving only 1 unknown force (DF) in the equation