Lecture 13, Oct 12, 2021

Truss Analysis

- Two methods for analyzing truss bridges:
  1. Method of joints, more suitable for analyzing forces over the whole bridge; uses only the translational equilibrium equations
  2. Method of sections, more suitable for quickly analyzing forces over sections of the bridge; uses all 3 equilibrium equations
- First the joint loads are determined from the distributed area loads
- The reaction forces from the supports are then calculated using equilibrium equations
- For a simply supported bridge with a roller on one end and a pin on the other end, the vertical load is shared equally between them due to symmetry, making each vertical reaction force equal to half the total load

Method of Joints

- The Method of Joints analyzes the bridge joint by joint
- Start at the end joints that meet the supports, since all other joints have too many unknown forces

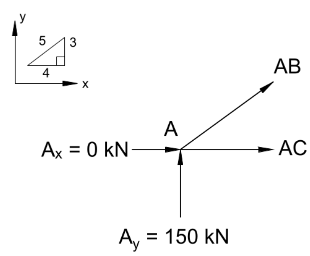

Figure 1: fbd at a joint

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- Once we have the free body diagrams we can calculate the forces at this joint; if force vectors form a closed loop when arranged tip-to-tail, the joint is in equilibrium
- With these forces we can now move on to other joints; note the order of joints is important, as some joints may still have too many forces to be solved
  - Since we're only using the two translational equilibrium equations, any joint that has 3 or more unknown forces is unsolvable at the moment
- Note the forces on the joints are applied *by* the members, not *to* the members; as a result, special care must be taken to tell whether a member is in tension or compression
  - Since the joint forces are applied by the members, the actual force applied to the members is the exact opposite by Newton's third law
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  - In the following image, BD is in compression, and BC is in tension
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- After repeating this process for half of the joints (the other half can be determined by symmetry), the final forces are presented:
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- Note that the sign convention is **tension is positive** and **compression is negative**

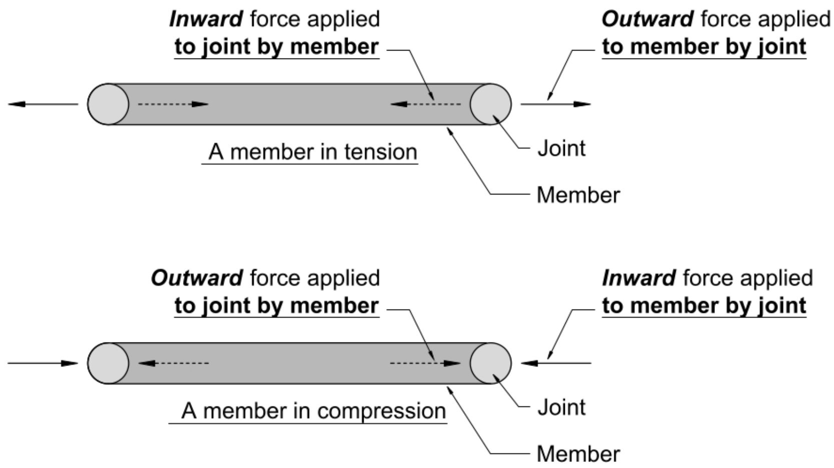

Figure 2: Newton's third law applied to the member

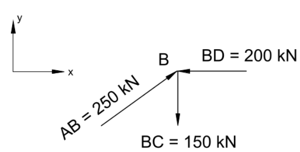

Figure 3: forces at a joint

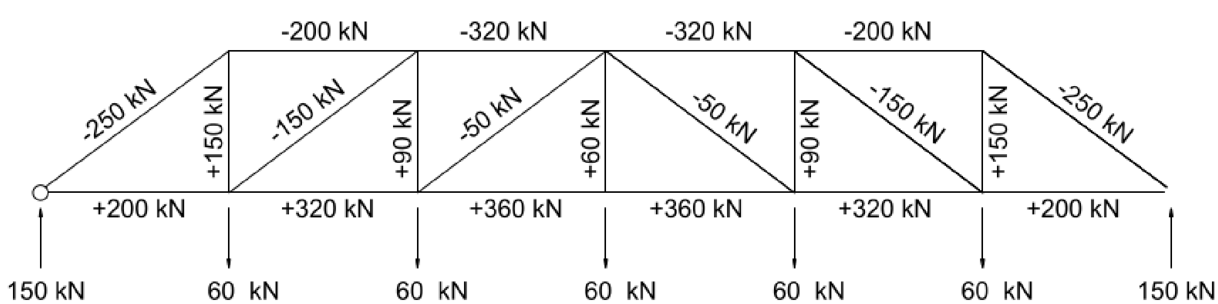

Figure 4: solved forces in the truss

Method of Sections

- 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:

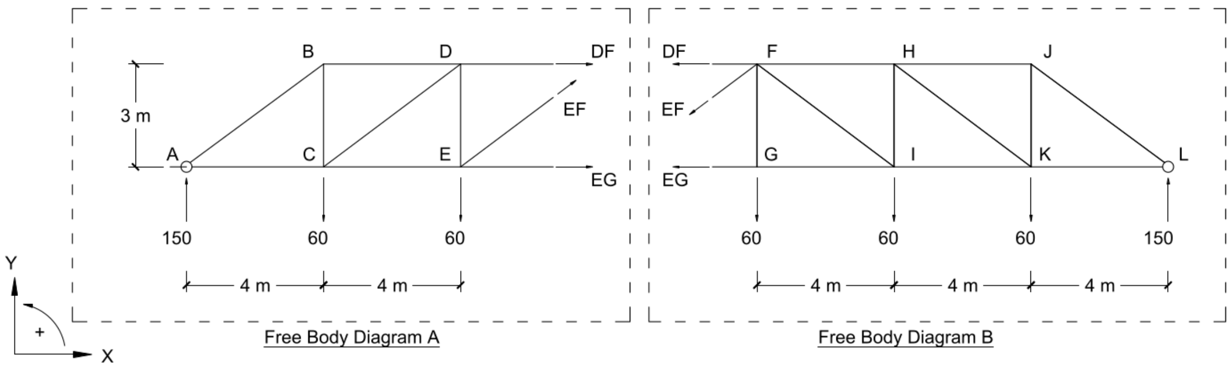

Figure 5: free body diagrams

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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