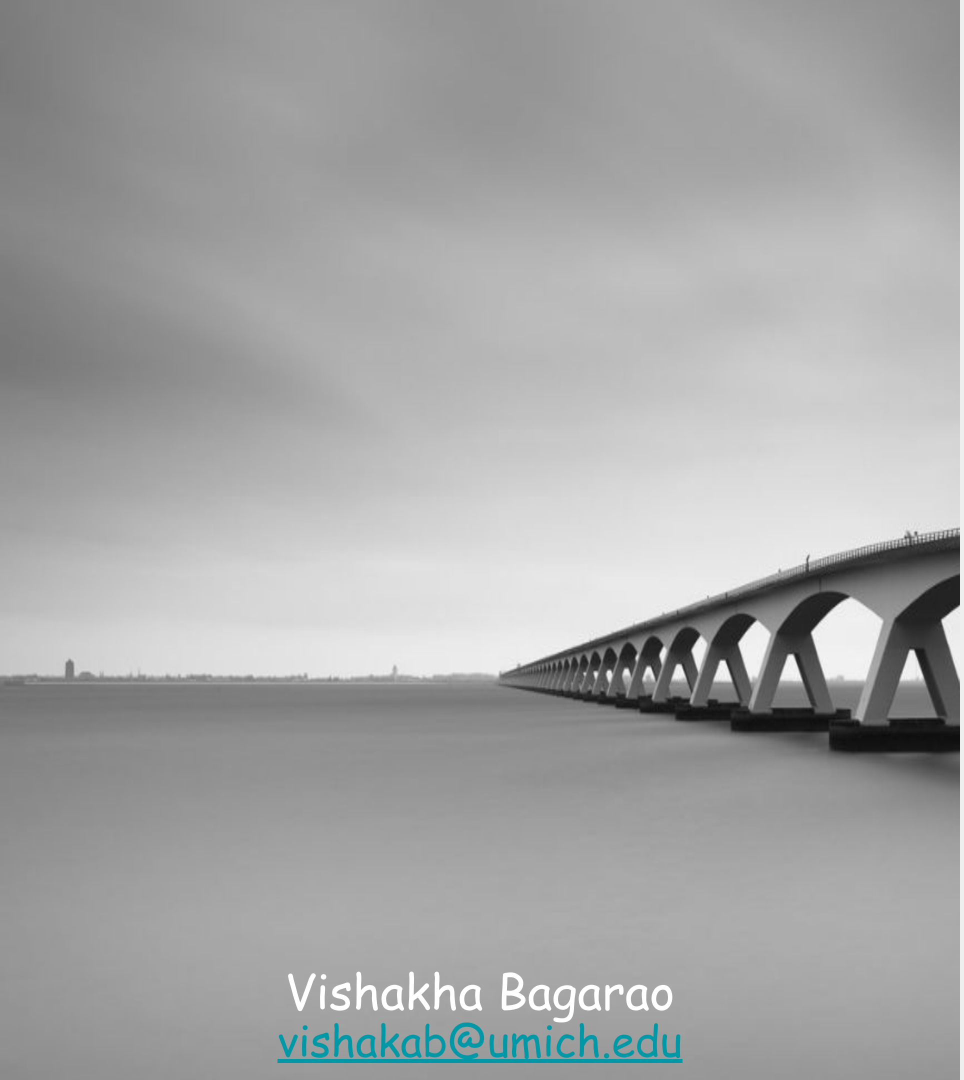
Arch 314- Structures I

Recitation 006

Vishakha Bagarao

27th Sept 2024



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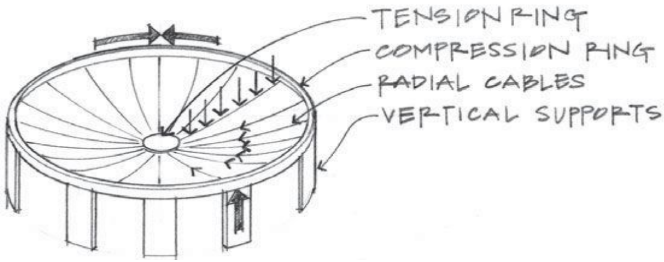
Contents

- Quick Recap
  - Cable Systems
    - Problem Set 06
  - Planar Truss (by joints)
- Lab 4- Truss Stability

Cables: Cables are highly efficient structural system.

Suspension Bridge- Golden Gate
San Francisco

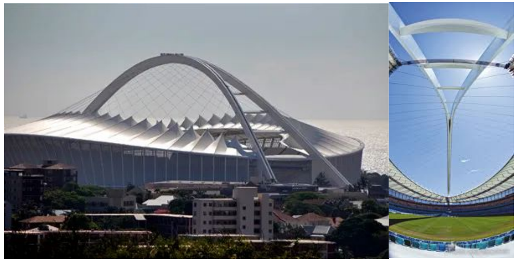
Cable Roof Structure- Spoked Wheel Cable
Roof, Bay Arena Leverkusen, Germany



Suspended Roof System

Transmission Cable Lines

Guy Wire



Arch tower cable supported roof, Moses
Mabhida Stadium, South Africa

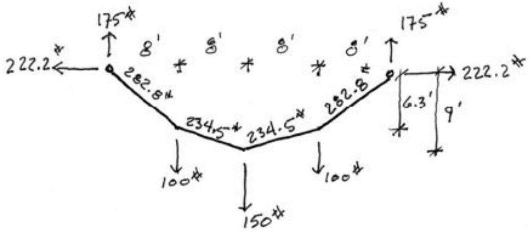
- Relatively light, virtually no rigidity or stiffness.
- No bending Moment- The moment is 0 at any point in the cable since the cable cannot support flexure.
- Cables can only support loads in tension and must always remain under tension to ensure stability.

Cable Forces

Types of Cable Forces

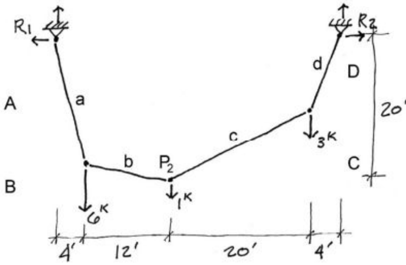
Even Supports – Symmetric Loading

If symmetric, then the reactions at each end are equal



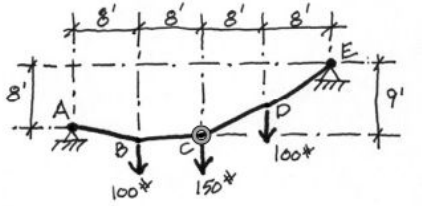
Even Supports – Asymmetric Loading

If asymmetric, then the vertical reactions are not equal.
With no applied horizontal loads, the horizontal reactions are equal.



Uneven Supports

Each joint is analyzed as a concentric force system.



Formulas:

- Horizontal and vertical components:
  - $\sum M = 0$
  - $\sum F_y = 0$
  - $\sum F_x = 0$

- Total force in member:
  - $F = \sqrt{F_x^2 + F_y^2}$

- Heights:
  - Slope is proportional to the forces;
  - $A_x / A_y = E/A$

Example:

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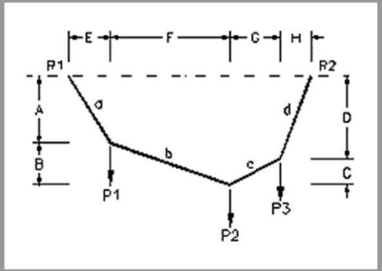
6. Cable Systems

For the cable loaded as shown, determine the horizontal and vertical components of each end reaction, and the tensile force in each cable segment.



DATASET: 1 -2- -3-

Length E	4 FT
Length F	17 FT
Length G	17 FT
Length H	4 FT
Center height (A + B)	21 FT
Force P1	4 KIPS
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Problem Menu

Problem Set 06

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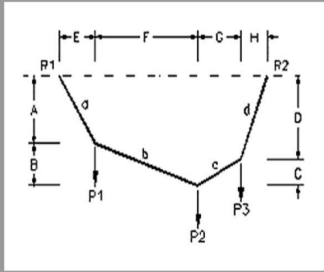

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Problem Menu

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1 to 4. Horizontal & Vertical components of R_1 & R_2.

$$\Sigma M_{R_2} = R_{1y}(4+17+17+4) - P_1(17+17+4) - P_2(17+4) - P_3(4)$$

$$0 = R_{1y}(42) - 4(38) - 6(21) - 1(4)$$

$$= R_{1y}(42) - 282$$

$$\therefore R_{1y} = \frac{282}{42} = +6.7143 \text{ kips} \quad (\uparrow, +)$$

$$\Sigma F_y = R_{1y} - P_1 - P_2 - P_3 + R_{2y}$$

$$0 = 6.7143 - 4 - 6 - 1 + R_{2y}$$

$$\therefore R_{2y} = +4.2857 \text{ kips.} \quad (\uparrow, +)$$

$$\Sigma M_{P_2} = R_{1y}(4+17) - R_{1x}(21) - P_1(17)$$

$$0 = 6.7143(21) - R_{1x}(21) - 4(17)$$

$$\therefore R_{1x} = \frac{73.0003}{21} = -3.4762 \text{ kips} \quad (\leftarrow, -)$$

∵ − = to the left ; + = to the right ;

R_{1x} is going towards left.

$$\therefore R_{1x} = -3.4762 \text{ kips.}$$

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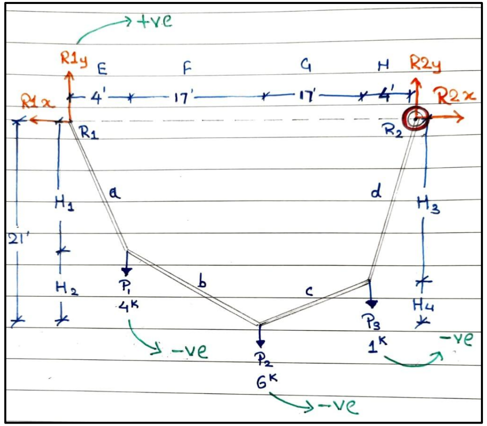

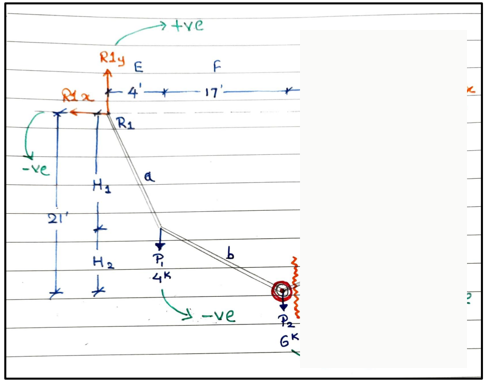

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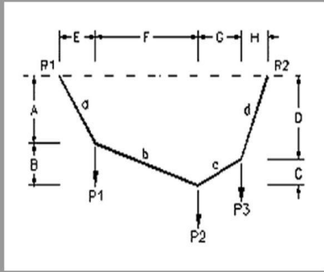

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$\Sigma F_x = -R1x + R2x = 0$

$\therefore R2x = R1x = +3.4762$ KIPS $(\rightarrow, +)$ //

\# 5. Total Force in member 'a'

$F_A = \sqrt{a_x^2 + a_y^2} = \sqrt{R1x^2 + R1y^2}$

$= \sqrt{(3.4762)^2 + (6.7143)^2}$

$\therefore F_A = 7.5608$ KIPS //

\# 6-7. Horizontal & Vertical forces in member 'b'

$\Sigma F_{by} = R1y - b_y - P_1$

$0 = 6.7143 - b_y - 4$

$\therefore b_y = 2.7143$ KIPS. //

$\Sigma F_{bx} = -R1x + b_x$

$\therefore b_x = R1x = 3.4762$ KIPS. //

\# 8. Total force in member 'b'.

$F_B = \sqrt{b_x^2 + b_y^2} = \sqrt{3.4762^2 + 2.7143^2}$

$\therefore F_B = 4.4104$ KIPS. //

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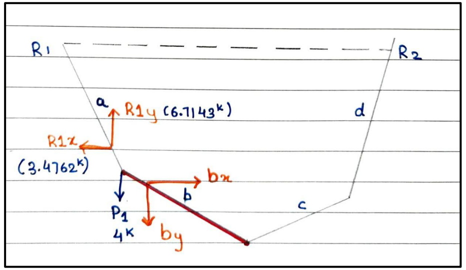

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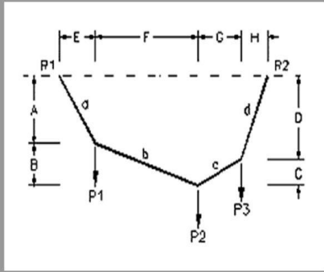

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9-10. Horizontal & Vertical forces in member 'c'.

$$\Sigma f_{cy} = R_{2y} - C_y - P_3$$
$$0 = 4.2857 - C_y - 1$$
$$\therefore C_y = 3.2857 \text{ KIPS} \;//$$

$$\Sigma f_{cx} = R_{2x} - C_x$$
$$\therefore C_x = R_{2x} = 3.4762 \text{ KIPS} \;//$$

11. Total Force in member 'c'.

$$f_c = \sqrt{C_x^2 + C_y^2} = \sqrt{3.4762^2 + 3.2857^2}$$
$$\therefore f_c = 4.7833 \text{ KIPS.} \;//$$

12. Total force in member 'd'.

$$f_d = \sqrt{d_x^2 + d_y^2} = \sqrt{R_{2x}^2 + R_{2y}^2}$$
$$= \sqrt{3.4762^2 + 4.2857^2}$$
$$\therefore f_d = 5.5183 \text{ KIPS.} \;//$$

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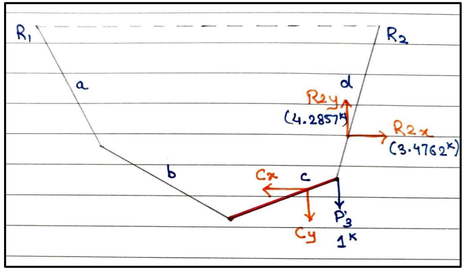

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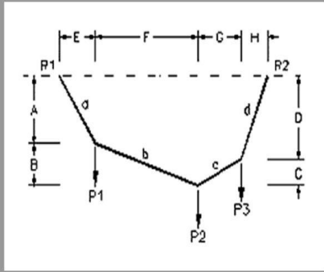

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\# 13-16. Heights A(H1), B(H2), C(H4), D(H3)

$$\frac{R_{1x}}{R_{1y}} = \frac{4}{H_1}$$

$$\frac{3.4762}{6.7143} = \frac{4}{H_1}$$

$$\therefore H_1 = 7.726'$$

$$H_1 + H_2 = 21$$

$$\therefore H_2 = 21 - 7.726$$

$$\therefore H_2 = 13.274'$$

$$\frac{C_x}{C_y} = \frac{17'}{H_4}$$

$$\frac{3.4762}{3.2857} = \frac{17}{H_4}$$

$$\therefore H_4 = 16.0684'$$

$$H_3 + H_4 = 21$$

$$\therefore H_3 = 21 - 16.0684$$

$$\therefore H_3 = 4.9315'$$

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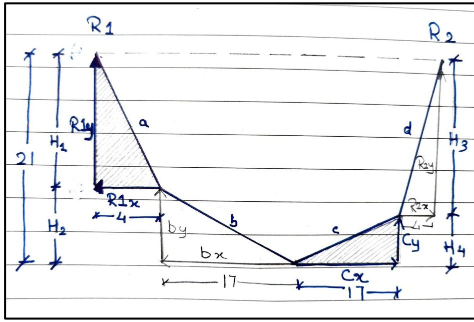
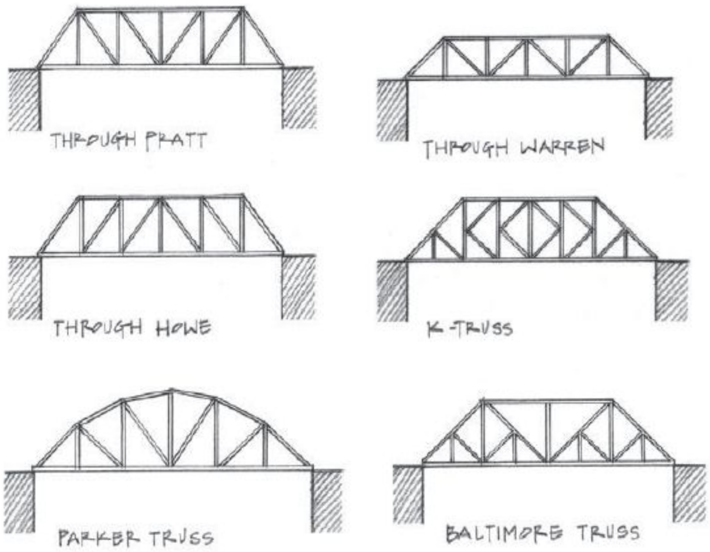


Truss: A truss represents a structural system that distributes loads to supports through a linear arrangement of various-sized members in patterns of planar triangles.

- A Rigid Structure made up of collection of straight members, where all joints are pinned.
- Since all joints are pinned, the members cannot carry bending moments, they can only carry axial loads.
- Each member has to be in equilibrium, Forces acting at each end of the member must be equal and opposite.
- Each member is either in tension or compression.



Example of Bridge Truss

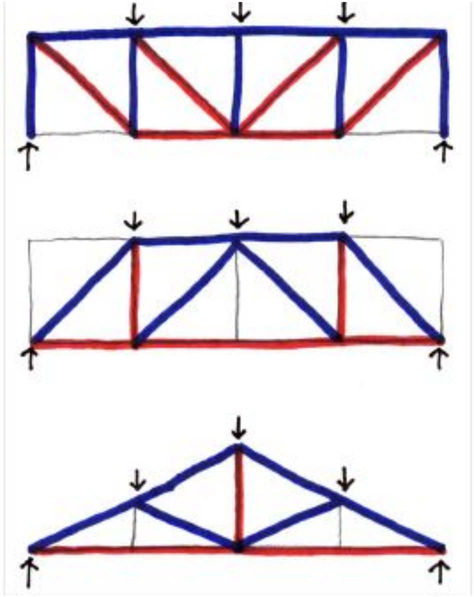
For typical gravity loading:
(tension=red compression=blue)

Top chords are in compression

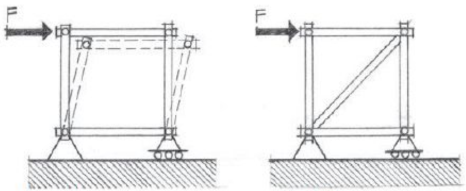
Bottom chords are in tension

Diagonals down toward center are in tension (usually)

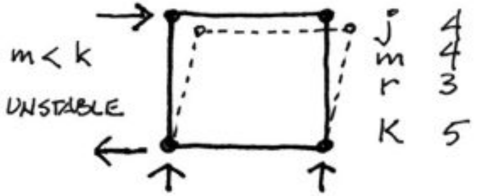
Diagonals up toward center are in compression (usually)



Stability and Determinacy



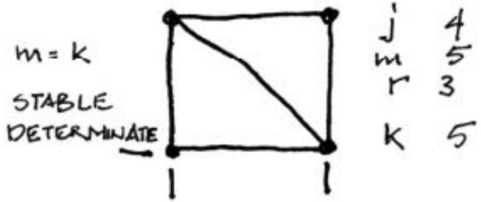
(a) Unstable. (b) Stable.



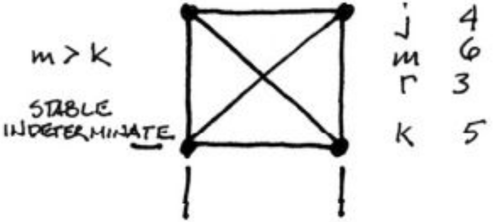
For:

- j joints
- m members
- r reactions (restraints)

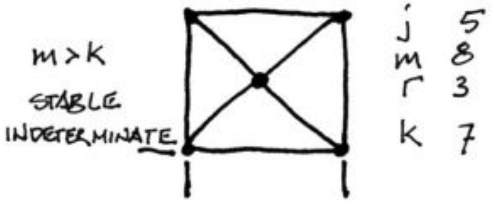
$$k = 2j - r$$



Where, k - Minimum no. of members in a truss system to be in equilibrium.
j - No of joints
r - No of reactions
m - No of members



- m < k unstable
- m = k stable and determinate
- m > k stable and indeterminate



Recitation- Lab 04

Arch 314

Name 2 ______________________

Name 3 ______________________

Truss Stability

Description

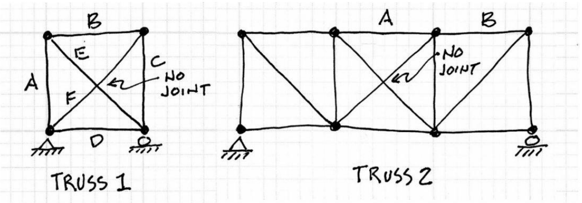
This project takes a look at the stability and instability of trussed structures based on member number and placement

Goals

To make use to the truss stability equation.
To observe limitations of the truss stability equation.

Procedure

1. Use the truss stability equation, k=2j-r , to determine whether Truss 1 is unstable, stable, or indeterminate.
2. Make a sketch of Truss 1 with member A removed. Based on the stability equation, what is the status of the truss now? Would you agree?
3. Now repeat this for each of members in Truss 1 one at a time. Does the truss remain stable in each case?
4. Use the truss stability equation to determine whether Truss 2 is unstable, stable, or indeterminate.
5. Make a sketch of Truss 2 with member A removed. Based on the stability equation, what is the status of the truss now? Would you agree?
6. Make another sketch of Truss 2 with member B removed. Based on the stability equation, what is the status of the truss now? Would you agree?
7. Try removing other members from Truss 2. Make a sketch of two of these showing one which remains stable and one which becomes unstable with one member removed.



$$k = 2j - r \quad \text{if} \quad \begin{cases} m < k & \text{then unstable} \\ m = k & \text{then stable and determinate} \\ m > k & \text{then stable and indeterminate} \end{cases}$$