EXAM 2
CIEG 301: STRUCTURAL ANALYSIS
FALL 2006

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Instructions:
1. NO talking.
2. Turn off cell phones.
3. Show ALL work. NO credit will be given for problems containing unsubstantiated calculations!
PROBLEM 1

[15 points]

The horizontal load P can act at any location along the length of member AC. Joint A is pinned; there is a moment connection at joint B; joint C is free and a roller exists at joint D.

(a) **Draw quantitative influence lines** for the horizontal reactions at A and D.

(b) **Indicate the location where a uniformly distributed load should be placed** to maximize (absolute value) both of these reactions.

(c) **Indicate the direction** these reactions (i.e., left or right) when they are maximized.

\[ \Sigma M_B = (1)(x-30) - A_x(30) = 0 \quad \text{for} \quad x \leq 30 \]

\[ A_x = 1 - \frac{x}{30} \]

\[ \Sigma M_D - (1)(x-30) + A_x(30) = 0 \quad \text{for} \quad x \geq 30 \]

\[ A_x = 1 - \frac{x}{30} \]

\[ \therefore \text{UDL should be placed between A and D for } A_x \text{ - max.} \]

This results in \( A_x \) acting to the left.

\[ \Sigma F_x = 1 - A_x - D_x = 0 \]

\[ D_x = 1 - A_x \]

\[ D_x = 1 - (1 - \frac{X}{30}) \]

\[ D_x = \frac{x}{30} \]

\[ \therefore \text{UDL should be placed between A and C for } D_x \text{ - max.} \]

\( D_x \) always acts to the left.
A new two-span bridge is being built across the Delaware River. Span One has a length of 88’ and Span Two has a length of 112’, resulting in the total length of the beams being 200’. However, the maximum length beam that can be shipped to the site is 140’. Thus, the girders must be fabricated in the field by splicing together two parts.

**Determine where the splice should be located** addressing the above practical limitations AND such that the moment at the splice due to a uniformly distributed load is minimized. Assume steel beams with constant cross-section.

\[
\Delta_B = \frac{w(l/2)^2}{24EI} \left( \frac{88^2 - 2(200)(88)^2 + 200^3}{36} \right)
\]

\[
\Delta_B = \frac{20,470 (10,000)}{1,000} \text{ ft}^3
\]

\[
\frac{f_{BB}}{f_{BB}} = \frac{152(l/2)^2}{2(200) l} \left( \frac{2l^2 - 112^2 - 88^2}{200^3} \right)
\]

\[
\frac{f_{BB}}{f_{BB}} = \frac{6,130(10,000)}{200^3} \text{ ft}^3
\]

\[
B_x = -\frac{6\Delta_B}{f_{BB}}
\]

\[
B_y = 12l \cdot 4l \omega \text{ (ft) (l)}
\]

\[
\Delta H_k = \omega (200l) \Delta B - (126.4l)(88) - C_y (200) = 0
\]

\[
C_y = 44.37 \omega \text{ (ft)}
\]

\[
\sum f_y \Rightarrow A_y = 200 \omega - 126.4l \omega - 44.4l \omega = 29.2 \omega
\]

\[
V: \text{ Span 2} = (29.2 - x_2) \omega
\]

\[
M: \text{ Span 1} = \left(29.2 \cdot \frac{x_2^2}{2} + C_y \right) \omega
\]

\[
M_{(\text{Span 1})} = \frac{88^2}{2} + 29.2 \cdot \frac{x_2}{2}
\]

\[
\text{Roots: } x_1 = 0, 58.8
\]

The splice should be located 58.8’ to the left of C, here the moment is zero and two splicing pieces at 88.8’ and 112.2’ can be used, satisfying all requirements.
Problem 3

Cable ABCD supports a crane rail with a self weight of 1800 lb. The maximum sag is 6.5 ft. Ignore load factors.

(a) What is the maximum tension in the cable considering dead load only? (20 points)

(b) The maximum capacity of the crane is 10 kip. What is the maximum tension in the cable due to live load? Note that the crane travels between E and F such that 0 ≤ x ≤ 12. (20 points)
One potential approach:

\[
\sum_{i=0}^{4} M_i \cdot (1 - \frac{x}{12})^2 + (1 - \frac{x}{12}) (17) - A_y (21) = 0
\]

1. L. \( A_y = \left( \frac{5}{12} \cdot V + 17 - \frac{17}{12} \cdot V \right) / 21 \)

1. L. \( A_y = \frac{17 - V}{21} \)

\[
T_{\text{max}} = T_{AB} = A_y \left( \frac{\sqrt{25.25}}{6.5} \right)
\]

\[
A_y \cdot \text{max} = \left( 17 - \left( \frac{17 - V}{21} \right) \right) / 21 = 8.195 \text{ k}
\]

\[
T_{\text{max}} = 8.195 \left( \frac{\sqrt{25.25}}{6.5} \right) = 9.5 \text{ k}
\]
Problem 1

Use the arch shown below to complete parts (a), (b), and (c). In the schematic, A is a pinned support, B is a hinge, and C is a roller support.

(a) **Indicate the direction** (e.g., left, right, up, down) of all external reaction forces. (5 points)

See schematic above.

or, Ax and Ay can be resolved into a single reaction (R_A) acting parallel to the tangent at the arch at A.

(b) **What would be the consequence** of removing the cable from this structure? (5 points)

The structure would be unstable and would collapse.

(c) The arch shown is not a funicular arch. **Qualitatively sketch** the shape that would result in a funicular arch for the loading shown. (5 points)
1. In the method of consistent deformations, **explain** how the compatibility equations are modified to account for support displacements.

   The compatibility **equations** are set equal to the support displacement *instead* of zero.

2. **List** the primary disadvantage and two advantages of statically indeterminate structures.

   **Primary disadvantage:** more sensitive to support settlements, temp. changes, and fabrication errors.

   **Advantages:**
   - Capacity for redistribution
   - Less deflection
   - Lower member stresses
   - More aesthetically pleasing