Load Combinations Worksheet Answers

Show your work as you use the following load combinations to solve the problem:

**Load Combinations**
1. Ultimate load = dead load + live load + snow load
2. Ultimate load = dead load + live load + wind load (or earthquake load)
3. Ultimate load = dead load + live load + wind load + (snow load ÷ 2)
4. Ultimate load = dead load + live load + snow load + (wind load ÷ 2)
5. Ultimate load = dead load + live load + snow load + earthquake load

Calculate the five ultimate loads resulting from each combination for the following loads:

- Dead load = 100,000 lbs
- Live load = 30,500 lbs
- Wind load = 5,020 lbs
- Snow load = 400 lbs
- Earthquake load = 5,000 lbs

**Answer**
- Load combination 1: = 100,000 + 30,500 + 400 = 130,900 lbs
- Load combination 2: = 100,000 + 30,500 + 5020 (or 5000) = 135,520 lbs with wind load
  - OR = 135,500 lbs with earthquake load
- Load combination 3: = 100,000 + 30,500 + 5020 + (400 ÷ 2) = 135,720 lbs
- Load combination 4: = 100,000 + 30,500 + 400 + (5020 ÷ 2) = 133,410 lbs
- Load combination 5: = 100,000 + 30,500 + 400 + 5000 = 135,900 lbs

From the five ultimate loads calculated above, for which ultimate load amount must the structure be designed?

**The structure must be designed for 135,900 lbs which is obtained with load combination 5.**
Problem 1: Using the highest load calculated from the first page, calculate the required area of a rectangular shape made of concrete if it is a pier or a column with a compression force acting on it. If \( L = 10 \) inches, what must \( B \) be equal to?

The maximum compressive strength of this concrete is \( 4,000 \) lbs/in\(^2\). Use the following equations to complete the problem. Show all work and calculations.

Highest ultimate load = (max. compressive strength) \( \times \) (cross-sectional area)

Cross-sectional area = \( B \times L \)

Problem 1 cross-sectional area.

Answer

Highest ultimate load = \( 135,900 \) lbs

Cross-sectional area = highest ultimate load \( \div \) max. compressive strength
Cross-sectional area = \( 135,900 \) lbs \( \div \) \( 4,000 \) lbs/in\(^2\)
Cross-sectional area = \( 33.975 \) in\(^2\)

If \( L = 10 \) inches,

\( B = \) cross-sectional area \( \div \) \( L \)

\( B = 33.975 \) in\(^2\) \( \div \) 10 inches

\( B = 3.3975 \) inches
Problem 2A: Using the highest load calculated from the first page, calculate the required area of the circular shape made of concrete if it is a pier or a column with a compression force acting on it. What is the radius of this circle? The maximum compressive strength of this concrete is 5,000 lbs/in².

Problem 2B: Using the highest load calculated from the first page, calculate the required cross sectional area of the I-shape made of steel if it is a pier or a column with a tension force acting on it. The maximum tensile strength of this steel is 50,000 lbs/in².

Use the following equations to complete the problem. Show all work and calculations.

Highest ultimate load = (max. compressive strength) x (cross-sectional area)
Cross-sectional area of circle = π x (radius)²

Highest ultimate load = (max. compressive strength) x (cross-sectional area)

Problem 2 cross-sectional areas.

Answer
Highest ultimate load = 135,900 lbs

For the circular shape:
Cross-sectional area = highest ultimate load ÷ max. compressive strength
Cross-sectional area = 135,900 lbs ÷ 5,000 lbs/in²
Cross-sectional area = 27.18 in²
Radius of circle = square root of (cross-sectional area of circle ÷ π)
Radius of circle = square root of (27.18 in² ÷ 3.14)
Radius of circle = 2.942 inches

For the I-shape:
Cross-sectional area = highest ultimate load ÷ max. tensile strength
Cross-sectional area = 135,900 lbs ÷ 50,000 lb/in²
Cross-sectional area = 2.718 in²
Problem 3A: Using the highest load calculated from the first page, calculate the required $Z_x$ of the rectangular shape made of steel if it is a beam or a girder with a length equal to 20 feet (or 240 inches). $F_y$ of steel is equal to 50,000 lbs/in$^2$.

Problem 3B: What if the same beam was made of concrete with $F_y$ equal to 4,000 lbs/in$^2$.

Use the following equations to complete the problem. Show all work and calculations.

$$Z_x = \frac{\text{force} \times \text{length}}{(F_y \times 4)}$$

![Rectangular cross-sectional area]

Problem 3 cross-sectional area.

Answer

Highest Ultimate Load = 135,900 lbs

If made of steel:

$$Z_x = \frac{\text{force} \times \text{length}}{(F_y \times 4)}$$

$$Z_x = \frac{135,900 \text{ lbs} \times 240 \text{ inches}}{4 \times 50,000 \text{ lbs/in}^2}$$

$$Z_x = 163.08 \text{ in}^3$$

If made of concrete:

$$Z_x = \frac{\text{force} \times \text{length}}{(F_y \times 4)}$$

$$Z_x = \frac{135,900 \text{ lbs} \times 240 \text{ inches}}{4 \times 4,000 \text{ lbs/in}^2}$$

$$Z_x = 2038.5 \text{ in}^3$$