Activity: Demonstrating Load Distribution

Introduction

When a load is placed on anything stationary, there must be a counteracting force to keep it in place (Newton's Second Law). In structural and bridge engineering, this load must run through the elements and into the supports. The placement of the load relative to the supports will affect the path of the load and the behavior of the structure. This is a simple activity to show how load placement affects the way the load travels to supports.

Basic Activity: Two Scales, One Beam, and a Weight

The activity can be done in a number of ways.

Materials Needed

- Scale (Qty. 2 or 3) – used to measure the load in each support
- Supports (Qty. 2) – used to hold the beam
- Beam (Qty. 1) – used to span between the supports

<u>*Note*</u>: Make sure that your supports and beams are heavier than the load you plan on applying

Procedure

1. This activity can be an extension of the "Thin Plate Bridge" activity
    a. The beams developed in the Thin Plate Bridge activity can be used as the beam in this activity
    b. The beam can also just be a 2"x4" piece of wood or other stiff member.
2. Place the scales on a flat surface the proper distance apart (so that the beam will span from the centers of each scale)
3. Zero the scales
4. Place supports in the center of the scales and the beam on top of the supports
    a. Note that the beam should extend past the ends of the support
    b. Make a note of the weight that the scales are reading (this is Dead Load)
    c. Notice any difference between the scales, what could cause this difference?
5. Zero the scales with the supports and beam
6. Place a load on the center of the beam – How much load reads on each scale?
    a. Note: Additional load that you are applying onto the structure is generally considered Live Load
7. Move the load around on the beam – How does moving the load affect the readings on the scale?
8. Try placing the load directly over one of the supports – What does that scale read? What about the other scale?
9. Try placing the load outside of the two supports – What happens to the scale readings in this case?

Possibilities Modifications

1. *Guess/Estimate the Weight*: Decide on a few other places to put the weight; have the students try and guess/estimate what weight each scale will read when the load is applied at the different locations.
2. *Cantilever Member*: Place one of the supports within the beam (so that part of the beam is overhanging) → What happens when you apply a load on the cantilevered part of the beam?
3. *Three Supports*: Add a third support point between the other two. What happens when you place loads in different locations on this beam? Try switching out for other materials (with different stiffness). How do the different materials affect the scale readings?

Points to Emphasize

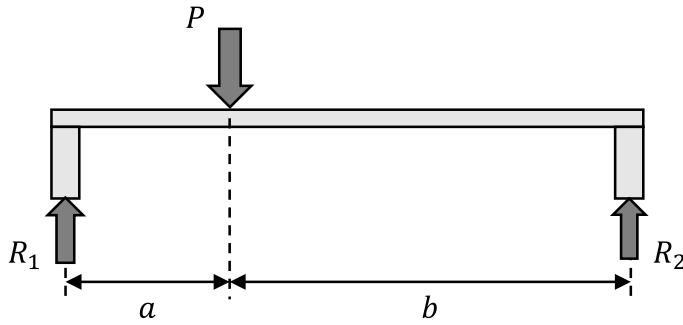There are several things that can be highlighted in this activity:

- *Effect of Load Placement on Support Reaction*: The load measured on the scale will be dependent on the magnitude and placement of the load on the beam. If the load is in the middle of the span, half the load will go to each support (scale). Moving the load can show this effect. This should be intuitive, but is a major part of structural engineering.
- *Types of Load*: There are many different types of loads that need to be accounted for in the design; the primary two are dead load (permanent loads) and live load (temporary loads). These two types of loads can easily be highlighted in the example.
- *Load Path*: One of the main goals of the structural engineer is to get all the loads in a structure down into the foundation elements (the scales in this example). More complex structures (e.g. multiple stories) can be made and loaded and show how the load still needs to get into the scales. Students can draw the structure and then draw arrows to show how the load transfers into the support.

Challenge Activities

- How can you make one of the scales read negative? (After zeroing the scales with the supports and beams on them)
- Cover up the scale readings and place a known weight somewhere on the beam. Can you estimate the load reading of each scale by using a ruler?

Math Applications

1. Calculating load on the supports (by proportions and introduce sum of forces and moments, algebra)

$$\sum F_y = 0$$

$$R_1 + R_2 - P = 0$$

$$\sum M_1 = 0$$

$$R_2(a + b) - P(a) = 0$$