Analytical and Experimental Evaluation of a SMARTBEAM
SMARTBEAMS are steel “I” shaped sections with voids in the middle.

- Make two cuts.
- Separate vertically.
- Weld back together

As a result of this process:

\[
\text{depth}_{\text{before}} < \text{depth}_{\text{after}} \\
\text{weight}_{\text{before}} = \text{weight}_{\text{after}} \\
\text{strength}_{\text{before}} < \text{strength}_{\text{after}}
\]

← reason for SMARTBEAM technology
Analytical & Experimental Evaluation of a SMARTBEAM
Project Overview

**Analytical Part**
Dr. Hampton
Calculate Bending Stresses

**Diagnostic Part**
Professor Char
Use Electronic Sensors to Measure Behavior

**Experimental Part**
Dr. Hampton
Test Behavior in Laboratory, Measure Response
Compare to Analytical Prediction

- $\sigma_{\text{max-comp}}$ linear distribution
- $\sigma_{\text{max-ten.}}$ linear distribution
- $\sigma = 0$
- neutral axis (NA)

Dr. Hampton
Create Mathematical Model of a Steel Beam and Predict Behavior

$\sigma_{\text{max-comp}}$ and $\sigma_{\text{max-ten.}}$ represent the maximum compression and tension stresses, respectively. The neutral axis (NA) is where the stress is zero.
• This project is fundamentally about the behavior of steel structures.
• The critical term in this project description is behavior.
• When engineers use the term behavior they look to describe the how the structure responds to externally applied loads.
• Examples of external loading are

<table>
<thead>
<tr>
<th>Truck Loads</th>
<th>Earth Quake Loads</th>
<th>Wind Loads</th>
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</thead>
<tbody>
<tr>
<td>![Truck Load Image]</td>
<td>![Earth Quake Load Image]</td>
<td>![Wind Load Image]</td>
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</table>
Structural response is physical and can be observed and measured.

Most notably:

- Does it **deform** with the load on it.
- How does it deform
  - stretch or compress
  - twist or bend
- Does it **return to its original** shape when the load is removed
- Does it safely resist the load or **does it fail**
- If it does fail, **how does this happen**.
Steel structures are typically composed of beams and columns.

Columns carry axial load and are typically in compression.

Beams carry transverse load and are typically in a state of bending.

Look at behavior of beams and columns.
• Now place a truck on the bridge & observe the bending deformation that results.

• Note that the bending deformation is different at different locations along the beam length.

• The bridge girder deflected shape is the result of bending and called the Elastic Curve.
Engineers study structural behavior in one of two ways
  • Mathematically - predict the behavior
  • Experimentally - measure the behavior

**Mathematical or Analytical Modeling**
  • Define the structure (load, support, material properties, member cross section)
  • Apply loads
  • Predict system behavior using engineering mechanics

**Experimental Evaluation**
  • Place structure in test frame under controlled conditions
  • Apply sensors to measure load, displacement and stress
  • Apply loads to test specimen
  • Measure response
• Now, the **mathematical model predictions** should be in reasonably good agreement with the experimental data.
• The objective of this project is to compare predicted and measured behavior for a beam in bending.

**Experimental Investigation**

**Mathematical (Analytical) Model**

- Downward Force Vectors Represent Load from Hydraulic Cylinders
- Reaction Force Vector Represents Bolt Support

\[
\text{Measured Experimental Behavior} = \text{Predicted Analytical Behavior}
\]