MODULUS OF RUPTURE (MOR) TESTING
The Modulus of Rupture formula can be derived simply by using basic statics and strength of material equations.

Let’s start with a beam of length $L$ loaded at mid-span with a force $F$ and is simply supported at the 2 ends of the beam. The reaction forces are $P_1$ and $P_2$. The cross section of the beam is rectangle and has a width of $b$ (dimension into the paper), and a depth (height or thickness of the cross section) of $d$. This loading configuration represents a simple 3 point bending test.

The beam will fail (rupture) at the point of maximum stress where it exceeds the ultimate strength of the material. In the 3 point bending test, the beam will fail at the point of maximum bending stress (maximum outer fiber stress) that exceeds the ultimate material strength.
**Maximum bending stress** in the beam is determined by the famous formula of $\frac{M \cdot c}{I}$, where $M$ is the bending moment, $c$ is the distance from the neutral axis to the outer fiber, and $I$ is the moment of inertia of the beam cross section.

It should be clear that the **maximum bending moment** is located at the **midpoint** of the beam (for a beam loaded at midspan) which can be determined by $P \frac{L}{2}$, where $L/2$ is the length from the support to the beam midspan. $P_1 = P_2 = F/2$ for a midspan loaded beam. For a symmetric cross section such as a rectangle, $d = \frac{d}{2}$, where $d$ is the distance from the center of the cross section to the *outermost* fiber). The moment of inertia $I$ for a rectangle cross section is $\frac{bd^3}{12}$.

Therefore, putting everything together:

$$\text{Maximum Bending Stress} = \frac{M \cdot c}{I} = \frac{(P \frac{L}{2} \cdot \frac{d}{2})}{\frac{bd^3}{12}} = \frac{(\frac{F}{2} \cdot \frac{L}{2} \cdot \frac{d}{2})}{\frac{bd^3}{12}} = \frac{3FL}{2bd^2}$$

For a *round pellet*, you substitute the moment of inertia $I$ for a circle which is $\frac{\pi}{4} \cdot r^4$, so:

$$\text{Maximum Bending Stress} = \frac{M \cdot c}{I} = \frac{(\frac{F}{2} \cdot \frac{L}{2} \cdot r)}{\frac{\pi}{4} \cdot r^4} = \frac{FL}{\pi r^3}$$
To evaluate green strength of the extruded bars, a Modulus of Rupture test was performed.

\[ \text{MOR} = \frac{WL}{\pi R^3} \]

\[ \text{MOR} = \text{Modulus of Rupture (lb/in}^2\text{)} \]

\[ W = \text{maximum load (lbf)} \]

\[ L = \text{distance between supports} \]

\[ \varnothing = \text{pellet diameter (in)} \]

\[ R = \text{pellet radius } \left(\frac{\varnothing}{2}\right) \]

**EXTRUSION PLASTICITY FACTOR (EPF)**

In order to evaluate the plastic nature of the material during extrusion, penetrometer readings are divided by lab extruder motor amps to get some quantitative value for ease of extrusion. This value is called EPF (Extrusion Plasticity Factor) and the higher the value, the higher the column stiffness for a given level of extrusion amperage.