MET-211 Lab 3 Group 7

Properties and Stress Concentrations

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Lab 3: Goals of the Lab

Properties and Stress Concentrations

Specimen in Universal Testing Machine (UTM)

1. Determine how much **variation** exists in the Elastic Modulus of a selection of steel samples due to alloy and geometry.
2. Determine the accuracy of **failure predictions** due to stress concentration.
3. Present the **results** of your investigation in the laboratory to the class so the data can be combined with others and compared.

1. Variation: Elastic Modulus

Determine how much variation exists in the Elastic Modulus of a selection of steel samples due to alloy and geometry.

Elastic Modulus (Young's Modulus)

(*Stiffness of a material*)

The modulus of elasticity, *E*, is a measure of the stiffness of a material determined by the slope of the straight-line portion of the stress-strain curve. It is the ratio of the change of stress to the corresponding change in strain. [textbook, p. 59]

$$E = \frac{stress}{strain} = \frac{\sigma}{\epsilon}$$

1. Variation: Typical Stress-Strain Curve

Determine how much variation exists in the Elastic Modulus of a selection of steel samples due to alloy and geometry.

Typical Stress-Strain Curve: Low Carbon Steel

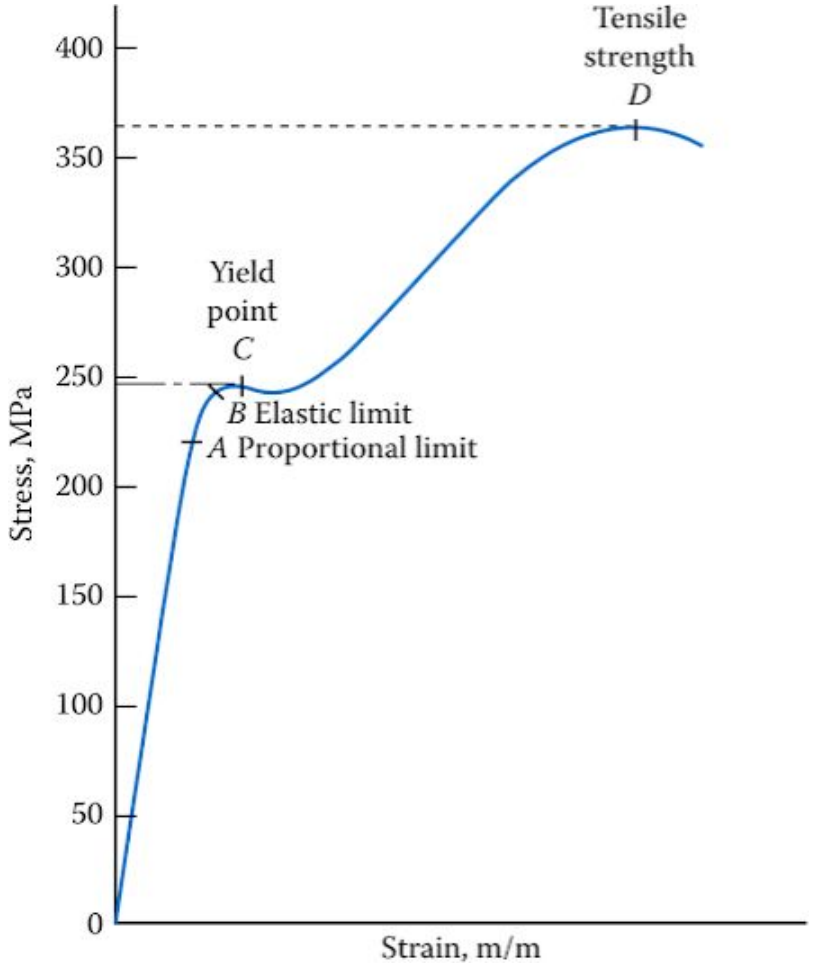
A. **Proportional Limit:**
Straight line indicates stress is proportional to strain.

B. **Elastic Limit:**
Material will return to original size and shape if load is removed. At higher stresses material is permanently deformed.

C. **Yield Point:** 248 MPa (36,000 psi)
Stress at which a noticeable elongation of the sample occurs with no apparent increase in load.

D. Tensile Strength: 365 MPa (54,000 psi)
Highest Value of apparent stress.

[textbook, pp. 56-57]



Source: Typical stress-strain curve for steel. [textbook, p. 57]

1. Variation: Specimen Material Properties

Determine how much variation exists in the Elastic Modulus of a selection of steel samples due to alloy and geometry.

AISI 12L14 Carbon Steel (UNS G12144) (Low Carbon Steel)

AISI (American Iron and Steel Institute)

	Metric	English
Density	7.87 g/cm3	0.284 lb/in³
Elastic modulus	**190-210 GPa**	27557-30458 ksi
Yield Point	**415 MPa**	60200 psi
Tensile strength	**540 MPa**	78300 psi
Elongation at break	10%	10%
Reduction of area	35%	35%
Poisson's ratio	0.27-0.30	0.27-0.30

Source: [aisi]

Material type verified with a Olympus X DELTA Professional Handheld XRF Analyzer

X-Ray Diffraction (XRD) is a laboratory-based technique commonly used for identification of crystalline materials and analysis of unit cell dimensions. [xrd]

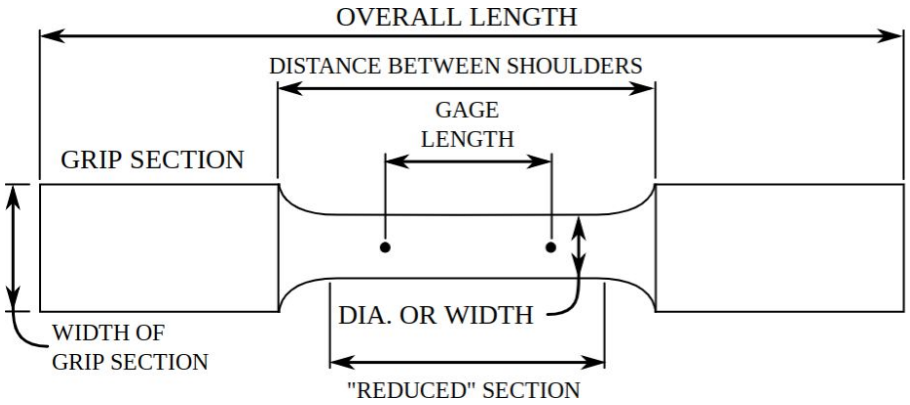
Source: [delta]

1. Variation: Typical vs. AISI 12L14

Determine how much variation exists in the Elastic Modulus of a selection of steel samples due to alloy and geometry.

	Typical Carbon Steel		AISI 12L14 Carbon Steel	
	Metric	**English**	**Metric**	**English**
Elastic modulus	207 GPA	30,000 ksi	190-210 GPa	27,557-30,458 ksi
Yield Point	248 MPa	36,000 psi	**415 MPa**	**60,200 psi**
Tensile strength	365 MPa	54,000 psi	**540 MPa**	**78,300 psi**
Elongation at break	9-36%	9-36%	10%	10%
Poisson's ratio	0.29	0.29	0.27-0.30	0.27-0.30

Typical test specimen geometry example.



Source: [wikipedia-tensile-testing]

1. Variation: Procedure Photo(s)

Scoring test specimens 25.4 mm (1 in) from center both sides for Extensometer.

1. Variation: Procedure Photo(s)

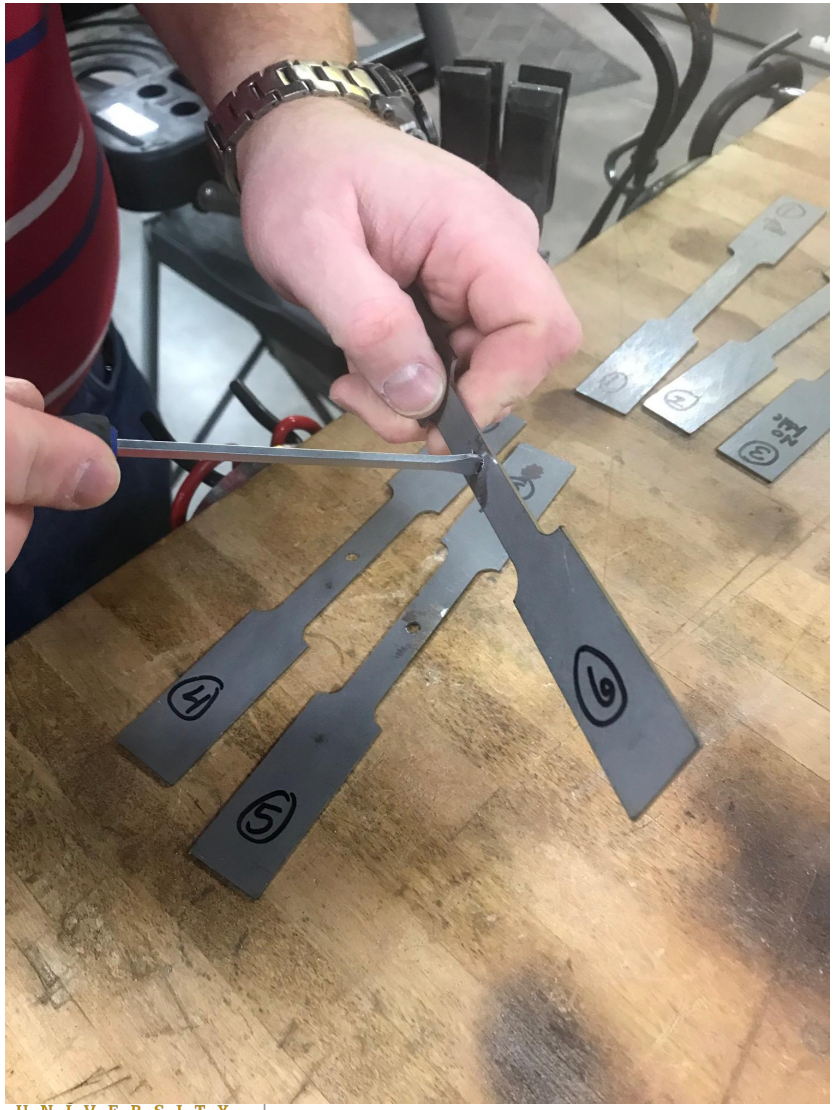
Marking test specimens (left for extensometer), (right for center punch).

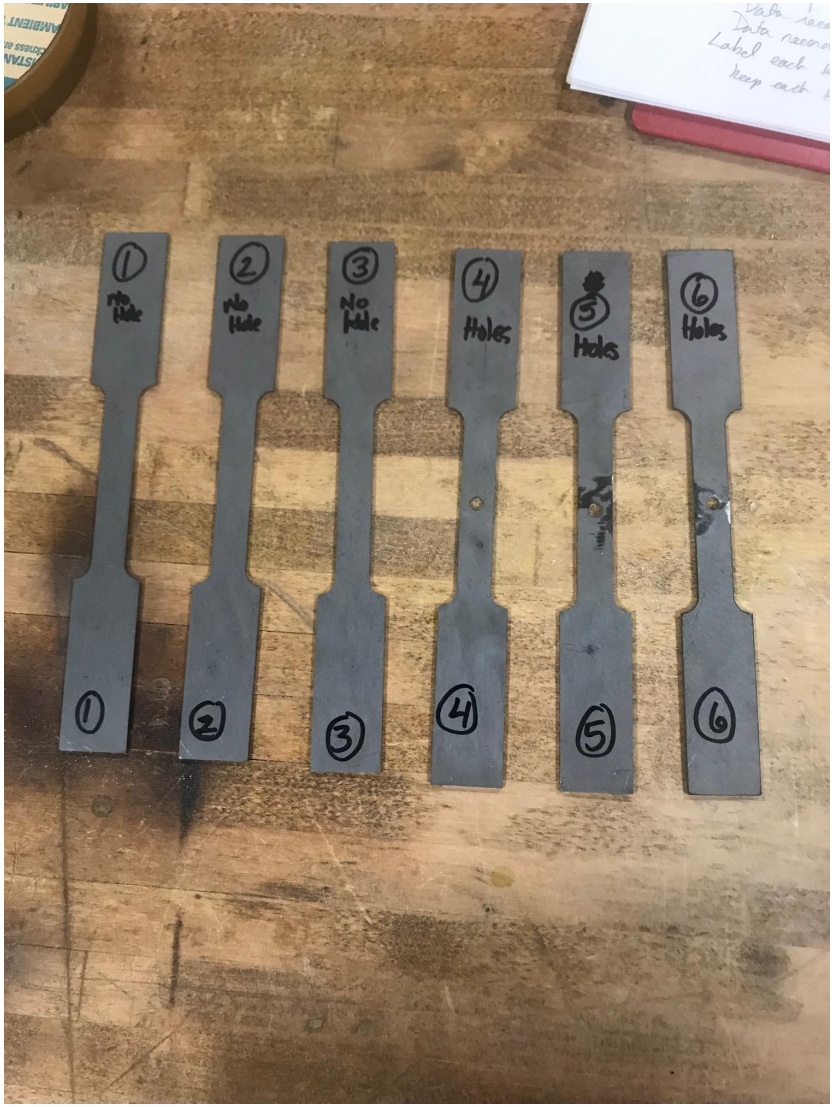
1. Variation: Procedure Photo(s)

Center marked (left) for drilling to correct holes not in center (right).

1. Variation: Procedure Photo(s)

Reaming out holes (left) and 6 test specimens (right).



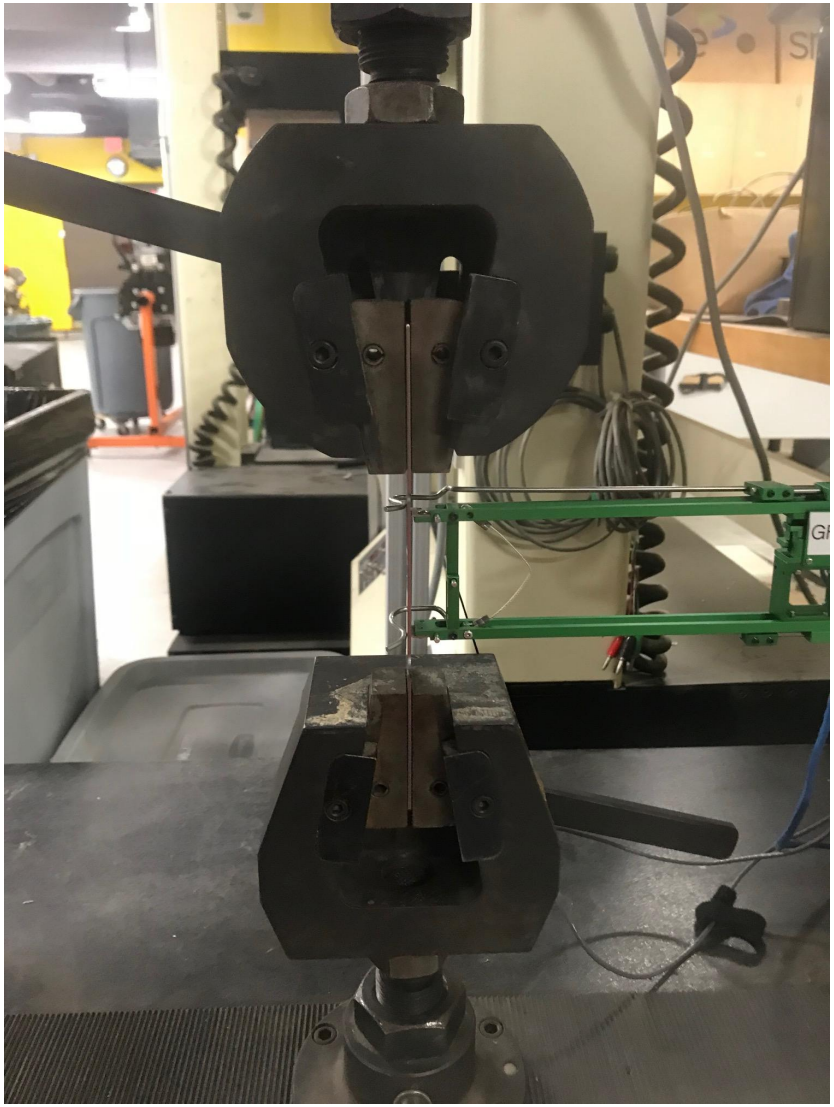


1. Variation: Procedure Photo(s)

Universal Testing Machine (UTM) set to low speed, speed dial constant for testing.

1. Variation: Procedure Photo(s)

Test to prevent slippage of test specimen (left), and specimen operator view (right).



2. Failure Predictions: Measurements

Determine the accuracy of failure predictions due to stress concentration.

Before: Necked Down Section Length (mm): 50.12

Before: Cross-Section Width (mm): 12.75

Before: Thickness (mm): 1.44

Before: Hole Diameter (mm): 5.06

Before: Overall Length (mm): 203.2

After: Overall Length No Holes (mm): 221.19

After: Overall Length With Holes (mm): 207.96

After: Necked Down Section Length No Holes (mm): 59.56

After: Necked Down Section Length With Holes (mm): 53.38

(Before - After) Overall Difference (mm): 13.23

Sample #	Necked Down Section Length (Before)(mm)				Cross-Section Width (mm)				Thickness (mm)			
	1	2	3	Average	1	2	3	Average	1	2	3	Average
1	50.74	49.59	50.27	50.2	12.79	12.74	12.76	12.76	1.46	1.54	1.4	1.47
2	49.48	49.72	49.54	49.58	12.76	12.74	12.75	12.75	1.44	1.5	1.47	1.47
3	50.05	50.24	49.64	49.98	12.71	12.76	12.75	12.74	1.44	1.45	1.46	1.45
4	51.28	49.3	49.68	50.09	12.71	12.73	12.74	12.73	1.44	1.47	1.45	1.45
5	50.89	49.98	50.69	50.52	12.75	12.74	12.76	12.75	1.44	1.44	1.45	1.44
6	50.13	50.22	50.31	50.22	12.72	12.75	12.76	12.74	1.43	1.42	1.42	1.42

Sample #	Hole Diameter (mm)				Necked Down Section Length (After)(mm)				W/ Hole	Overall Length	Overall Length (After)(mm)
	1	2	3	Average	1	2	3	Average			
1	None	None	None	None	66.12	66.38	65.56	66.02	No	203.2 mm	220.66
2	None	None	None	None	66.5	66.81	66.29	66.53	No	203.2 mm	222.25
3	None	None	None	None	66.2	65.97	66.21	66.13	No	203.2 mm	220.66
4	5.02	5.08	5.07	5.06	53.08	53.38	53.5	53.32	Yes	203.2 mm	206.38
5	5.01	5.07	5.05	5.04	53.8	53.42	53.38	53.53	Yes	203.2 mm	207.96
6	5.08	5.06	5.07	5.07	53.75	53.06	53.05	53.29	Yes	203.2 mm	209.55

2. Failure Predictions: Calculations

Determine the accuracy of failure predictions due to stress concentration.

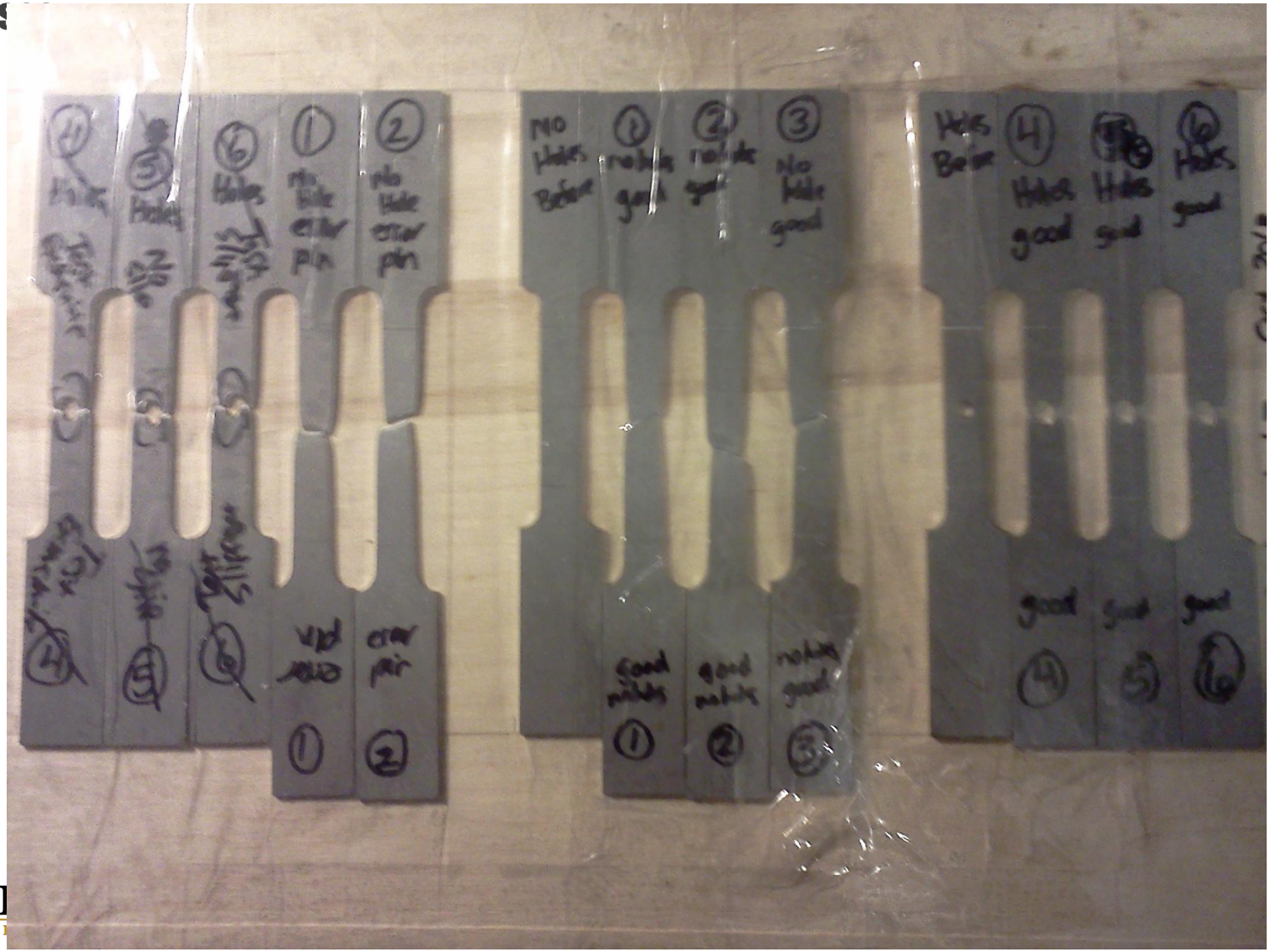
	Width (W) (mm)	Thickness (T) (mm)	Cross Sectional Area (W x T) (mm^2)	L_0= (mm)	L_f= (mm)	Percent Elongation = ((L_f - L_0)/L_0) x 100%
Before No Holes	12.75	1.44	18.36	50.12		
After No Holes					59.56	15.84%
Before With Holes	12.75-5.06 =7.69	1.44	11.07	50.12		
After With Holes					53.38	6.11%

2. Failure Predictions: Ideal

- The specimen should reach the yield point around as per the textbook based upon the material 248 MPa.

3. Results: Results Photo(s)

Specimens with smaller cross-sectional area elongate less and exhibit greater stress



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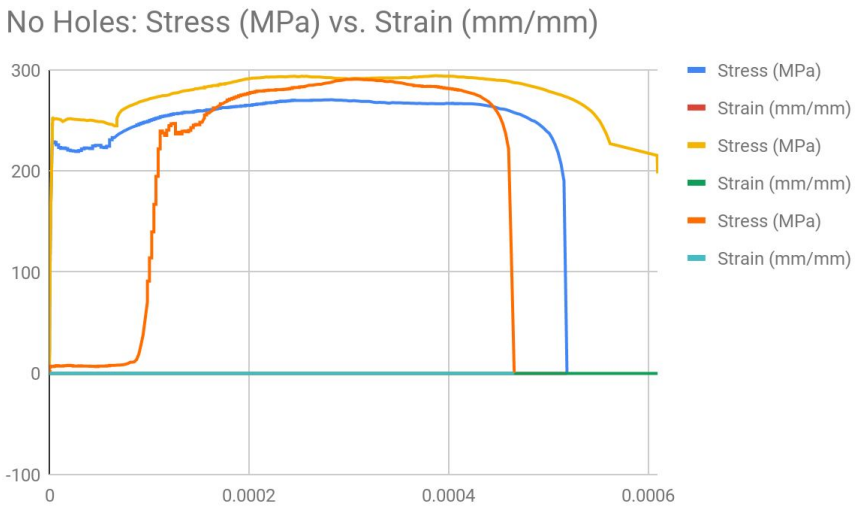
3. Results: Typ., Spec., Predicted, Actual

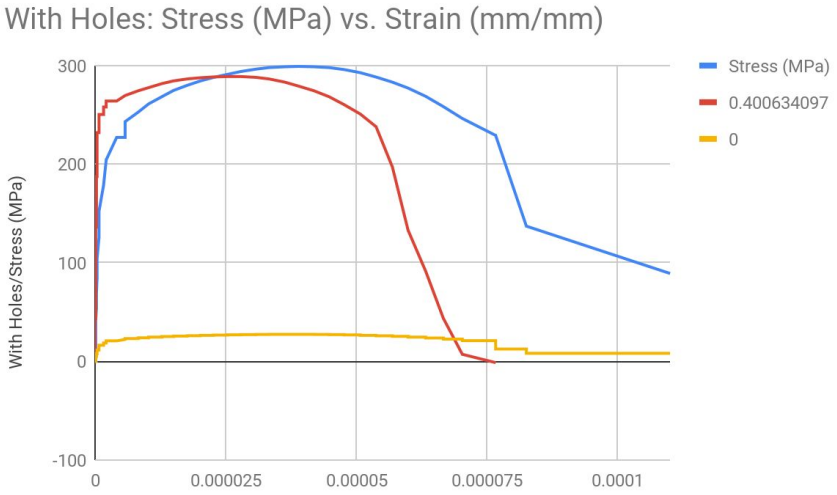
Present the results of your investigation in the laboratory to the class so the data can be combined with others and compared.

	Typical Carbon Steel	AISI 12L14 Carbon Steel	Predicted (Ideal)	Actual Results No Holes	Actual Results With Holes
	Metric	Metric	Metric	Metric	Metric
Elastic modulus	207 GPA	190-210 GPa	190-210 GPa	290 GPa	277 GPa
Yield Point	248 MPa	415 MPa	415 MPa	247 MPa	243 MPa
Tensile strength	365 MPa	540 MPa	540 MPa	270 MPa	290 MPa
Elongation at break	9-36%	10%	10%	31.5%	6.4 MPa
Poisson's ratio	0.29	0.27-0.30	0.27-0.30	1.1	0.18

3. Results: Graph(s)

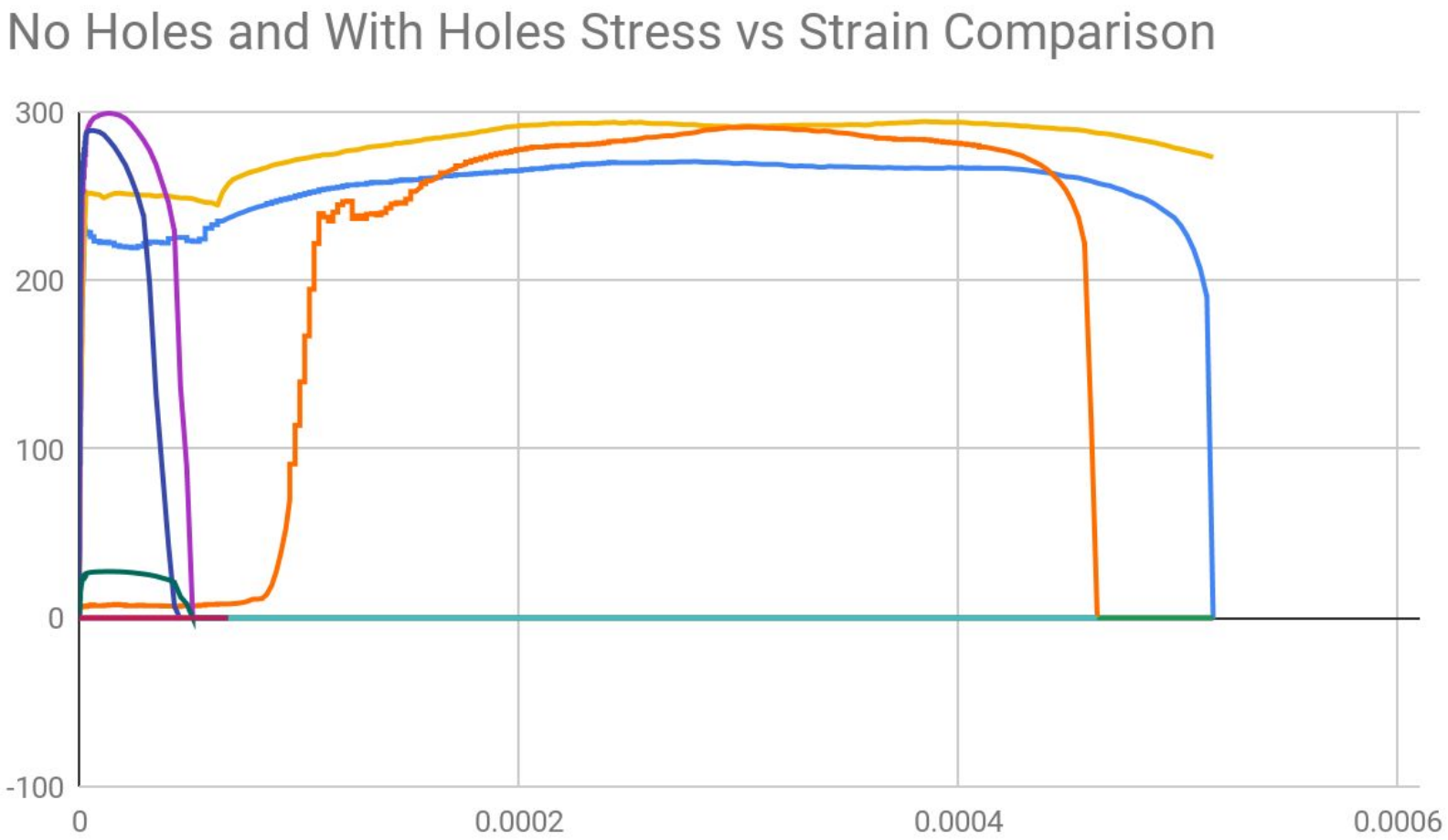
Stress vs Strain Graph Sample No Hole and With Holes





3. Results: Graph(s) Combined Data

Stress vs Strain Graph Sample with and without Hole



3. Results: Things we could do differently

- Start earlier
- Provide information to Professor Sisk to review
- Measure Cross Sectional Area after (however this is open to considerable measurement error)

References

[textbook] Mott, Robert L. Applied strength of materials. Upper Saddle River, N.J: Pearson/Prentice Hall, 2008. Print.

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[xrd] Definition: X-Ray Diffraction (XRD) | Open Energy Information
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