Acetone Polishing of ABS Test Results

Date: June 16, 2016

Objective: Determine Effect of Acetone on Mechanical Strength of 3D Printed Objects in Different Print Orientaions.

Equipment: TestrBot, PrintrBot, Digital Calipers, Digital Scale,

Procedure & Test Method: A total of 12 specimens were tested. (4 conditions were tested with 3 specimens representing each variable.)
6 specimens were printed in the 'side' orientation, while the other 6 specimens were printed in the 'vertical' orientation.
3 specimens from each orientation were treated with an acetone vapor polishing process and allowed to dry out for 72 hours. (3 hours of this time was spent in a dehydrator.) All other variables were held constant.

Specimens were tested via loading at constant displacement rate in 4 Point Bend configuration until failure occurred.

Conclusions & Discussion: The result of static stress testing to failure has shown that acetone treatment has two measurable effects on ABS 3D printed parts:
1) A chemical weakening of the material structure
2) A mechanical strengthing of layer bonds via the reduction of surface stress concentrations.

This testing has shown that effect #1 outweights effect #2 to decrease the part strength by 9% in all stress conditions *other than Z-axis loads* , where effect #2 outweights effect #1 to increase the part strength by 31%.

Regarding effect #1, these new results agree with previous testing done (by me) in effect but not in magnituide. My hypothesis is that the additional drying time that I gave the new specimens helped remove all traces of acetone which may have contributed to additional softening of the specimens in the previous testing.

The overall effect of Acetone vapor polishing on ABS effectively makes parts more isotropic. That is, they react more uniformly to applied loads from various driections by sacrificing strength in their strong axis to increase strength ion their weak axis.

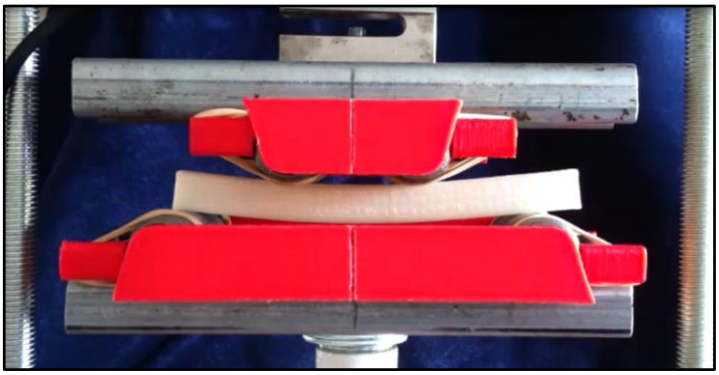

Photo 1: Test Setup

Photo 2. Specimens & Measurement Equipment

Photo 3. Close Up of Representative Specimens

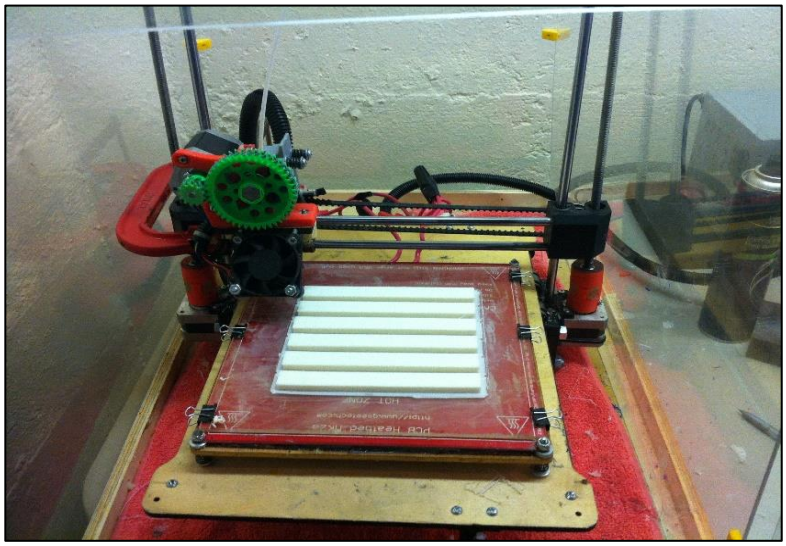

Photo 4. Printing In Horizontal Orientation

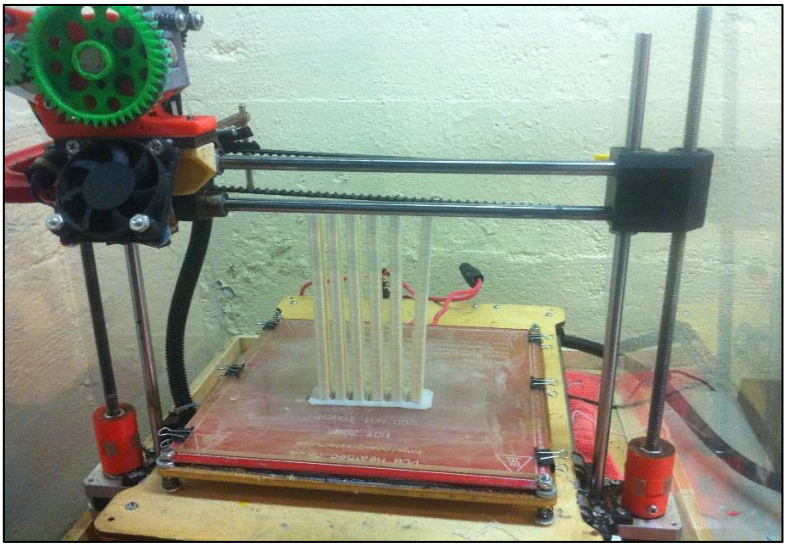

Photo 5. Printing In Vertical Orientation

Vapor Polishing Test Results 6-19-16

	Avg Yield Load (lb)	Avg Yield Stress (psi)	Avg Stiffness (lb/in)	Avg Ult Load (lb)	Avg Ult Disp (in)	Avg Ult Stress (psi)	Avg Mass (g)	Avg Ult Stress/Weight (psi/g)	Avg Stiffness per weight,(lb/in)
Normal, Horz	101.6	5797.5	469.0	113.7	0.3	**6493.7**	8.03	808.1	58.4
Treated, Horz	89.7	5077.1	415.9	104.8	0.3	**5931.8**	8.20	723.4	50.7
Normal, Vert	N/A	N/A	461.4	51.8	0.1	**2700.3**	11.80	228.9	39.1
Treated, Vert	N/A	N/A	438.5	66.0	0.2	**3549.4**	11.80	300.8	37.2

	Std Dev 2% Yield (lb)	Std Dev 2% Yield Stress (psi)	Std Dev Stiffness (lb/in)	Std Dev Ult Load (lb)	Std Dev Ult Disp (in)	Std Dev Ult Stress (psi)	Std Dev Mass (g)	Std dev Ult Stress/Weight (psi/g)	Std Dev Stiffness per weight,(lb/in)
Normal, Horz	2.7	282.7	12.0	7.3	0.048	516.6	0.058	60.3	1.1
Treated, Horz	2.5	293.4	18.6	0.1	0.021	170.7	0.000	20.8	2.3
Normal, Vert	N/A	N/A	43.5	14.2	0.014	757.3	0.173	64.9	4.1
Treated, Vert	N/A	N/A	2.7	6.9	0.017	327.6	0.000	27.8	0.2

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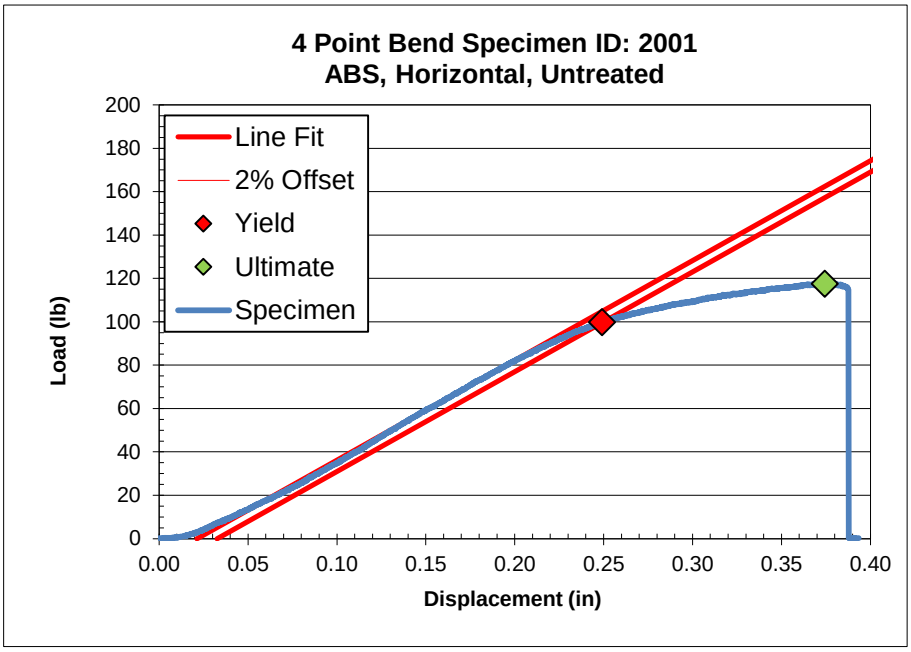
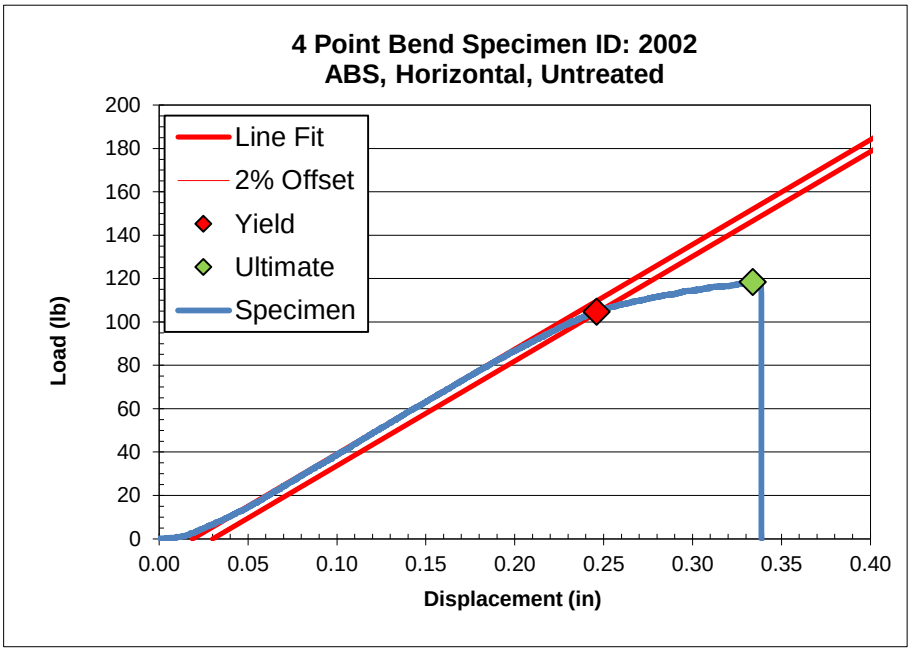


2% Yield:	99.81	lb
2% Yield Stress:	5633.5	psi
Stiffness:	459.8	lb/in
Ultimate Load:	117.59	lb
Displacement at Ultimate:	0.3532	in
Ultimate Bending Stress:	6636.7	psi



2% Yield:	104.70	lb
2% Yield Stress:	6123.9	psi
Stiffness:	482.6	lb/in
Ultimate Load:	118.37	lb
Displacement at Ultimate:	0.3151	in
Ultimate Bending Stress:	6923.7	psi

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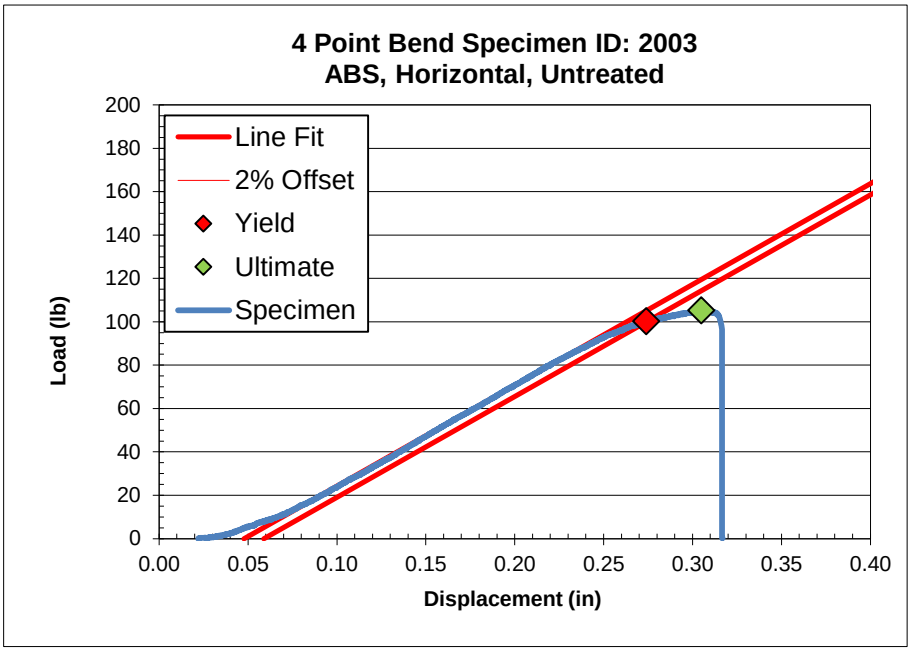
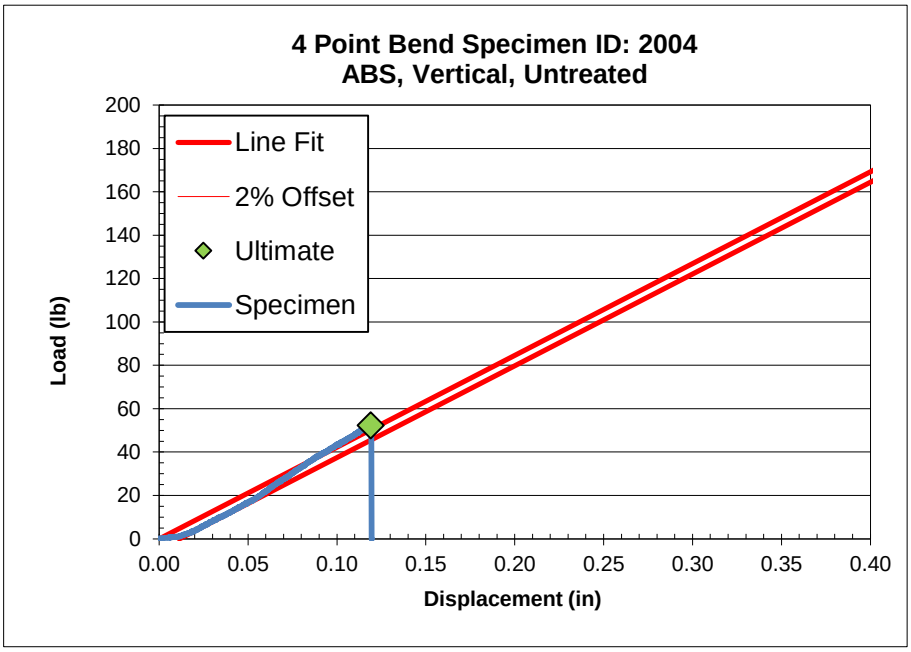


2% Yield:	100.20	lb
2% Yield Stress:	5635.0	psi
Stiffness:	464.6	lb/in
Ultimate Load:	105.28	lb
Displacement at Ultimate:	0.2571	in
Ultimate Bending Stress:	5920.6	psi



2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	423.1	lb/in
Ultimate Load:	52.35	lb
Displacement at Ultimate:	0.1190	in
Ultimate Bending Stress:	2675.9	psi

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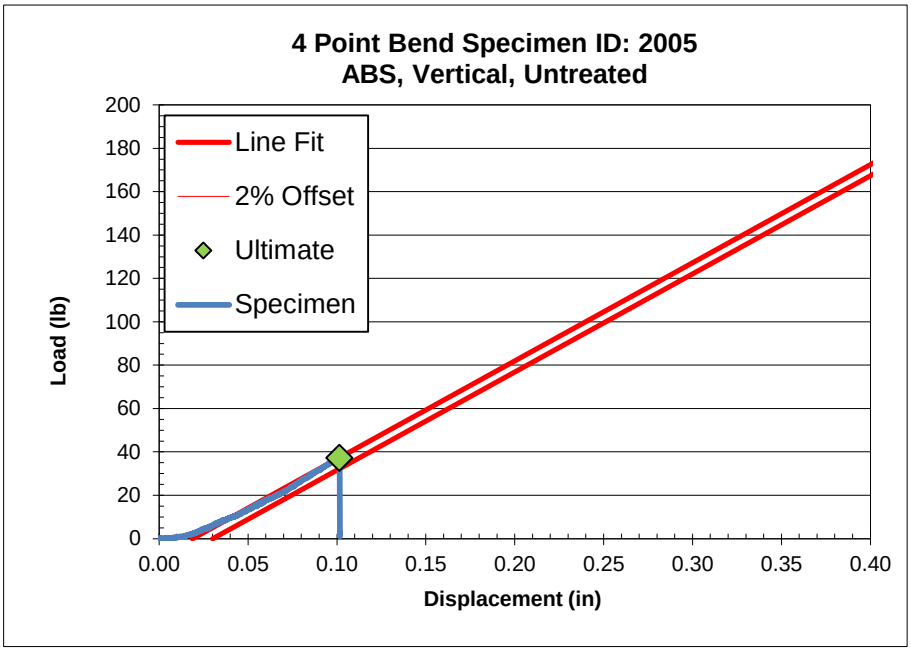
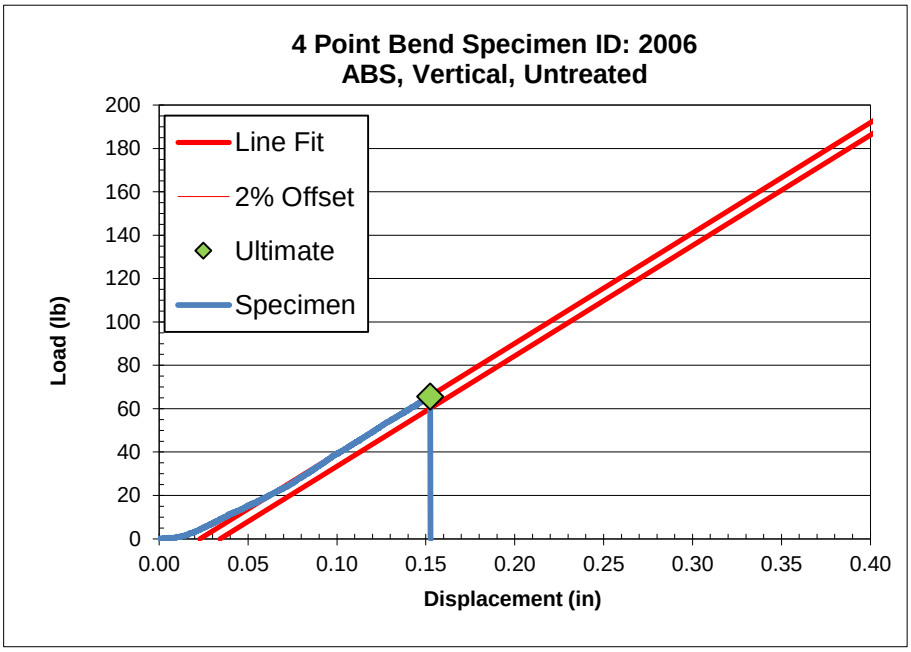


2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	452.4	lb/in
Ultimate Load:	37.31	lb
Displacement at Ultimate:	0.0825	in
Ultimate Bending Stress:	1955.4	psi



2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	508.8	lb/in
Ultimate Load:	65.63	lb
Displacement at Ultimate:	0.1296	in
Ultimate Bending Stress:	3469.5	psi

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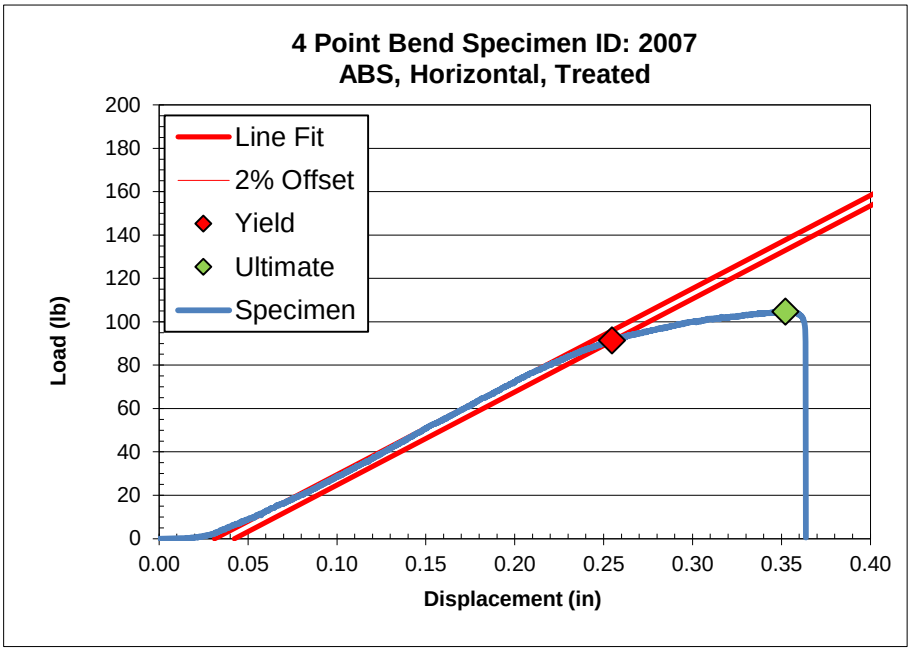
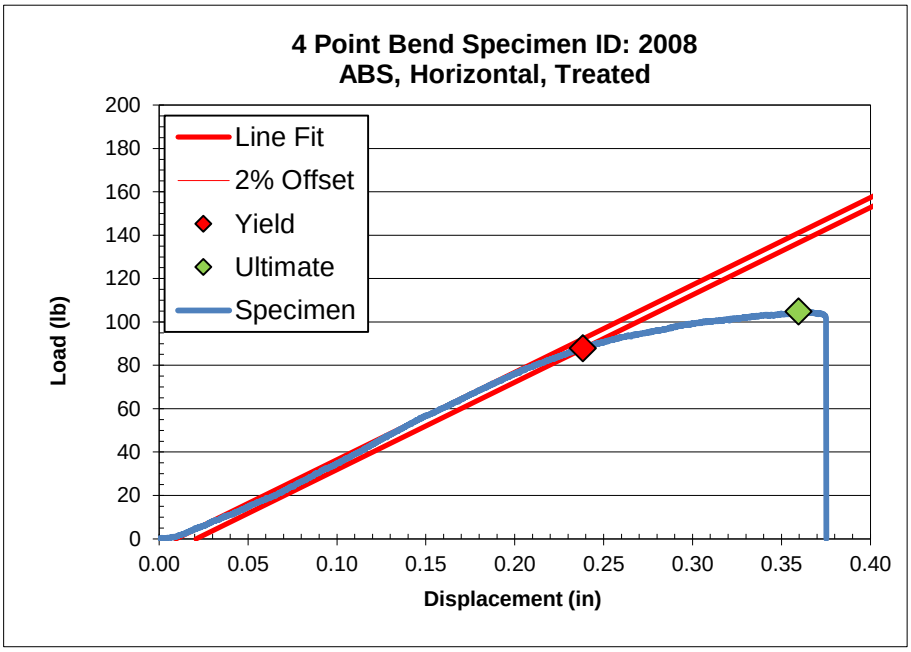


2% Yield:	91.41	lb
2% Yield Stress:	5284.6	psi
Stiffness:	429.1	lb/in
Ultimate Load:	104.70	lb
Displacement at Ultimate:	0.3211	in
Ultimate Bending Stress:	6052.5	psi



2% Yield:	87.90	lb
2% Yield Stress:	4869.7	psi
Stiffness:	402.8	lb/in
Ultimate Load:	104.89	lb
Displacement at Ultimate:	0.3503	in
Ultimate Bending Stress:	5811.1	psi

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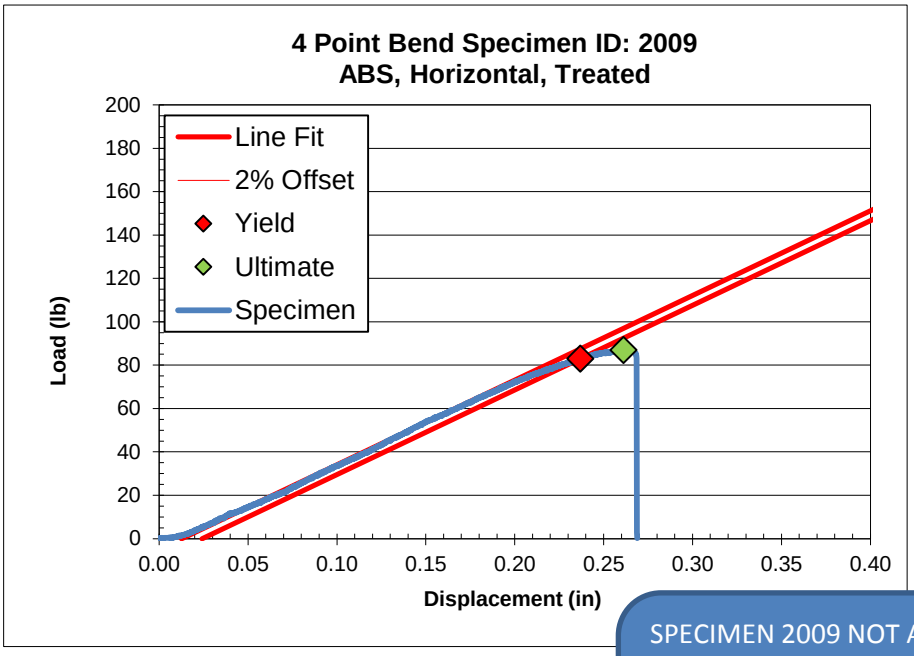
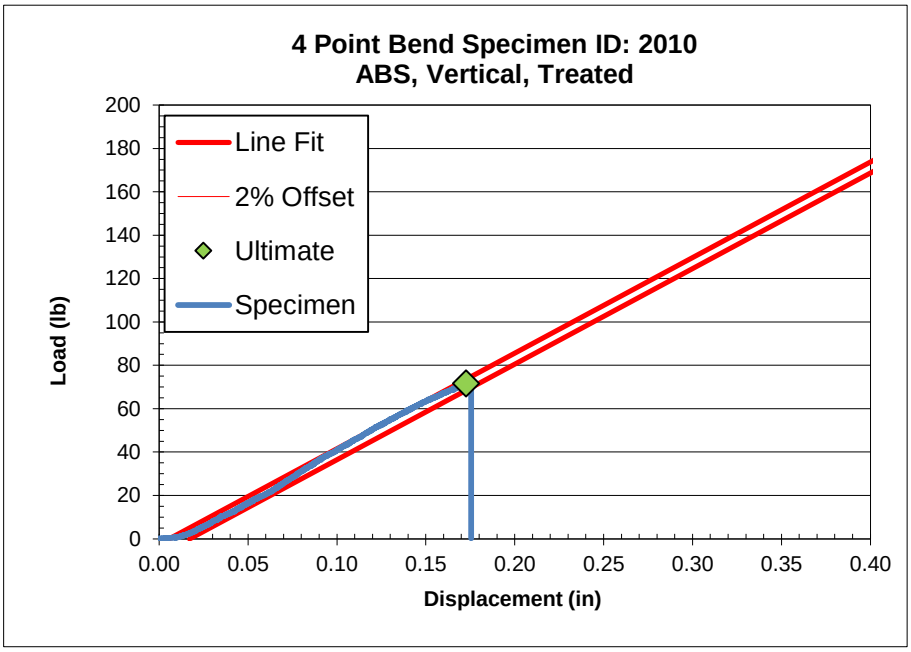


2% Yield:	83.01	lb
2% Yield Stress:	4406.7	psi
Stiffness:	390.1	lb/in
Ultimate Load:	86.92	lb
Displacement at Ultimate:	0.2486	in
Ultimate Bending Stress:	4614.0	psi

SPECIMEN 2009 NOT ADDED TO AVERAGE DATA BECAUSE IT DID NOT ACTUALLY FAIL. THE SPECIMEN ENDED UP FALLING OVER BUT DID NOT BREAK.



2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	440.5	lb/in
Ultimate Load:	71.69	lb
Displacement at Ultimate:	0.1669	in
Ultimate Bending Stress:	3833.5	psi

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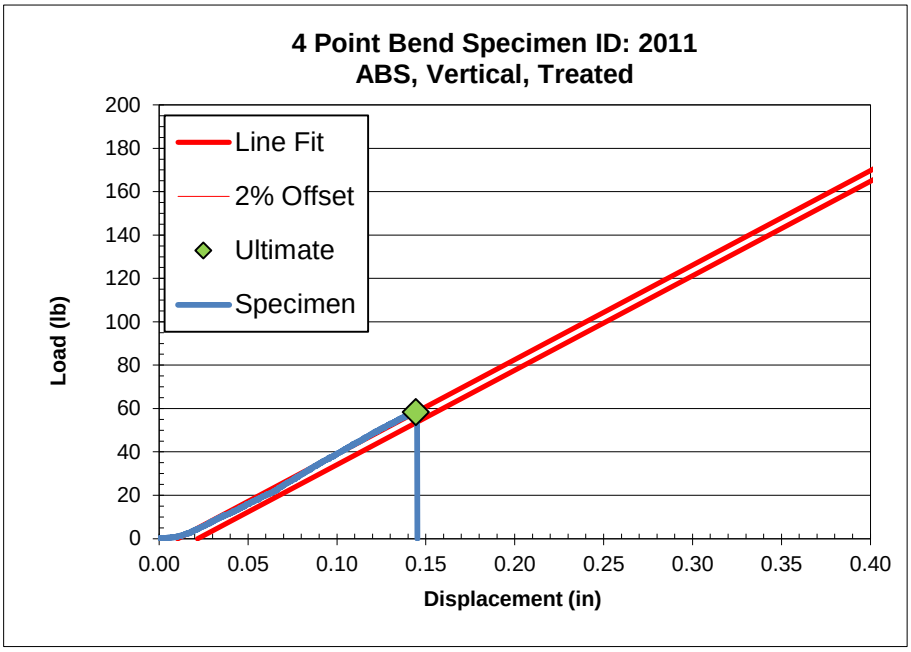
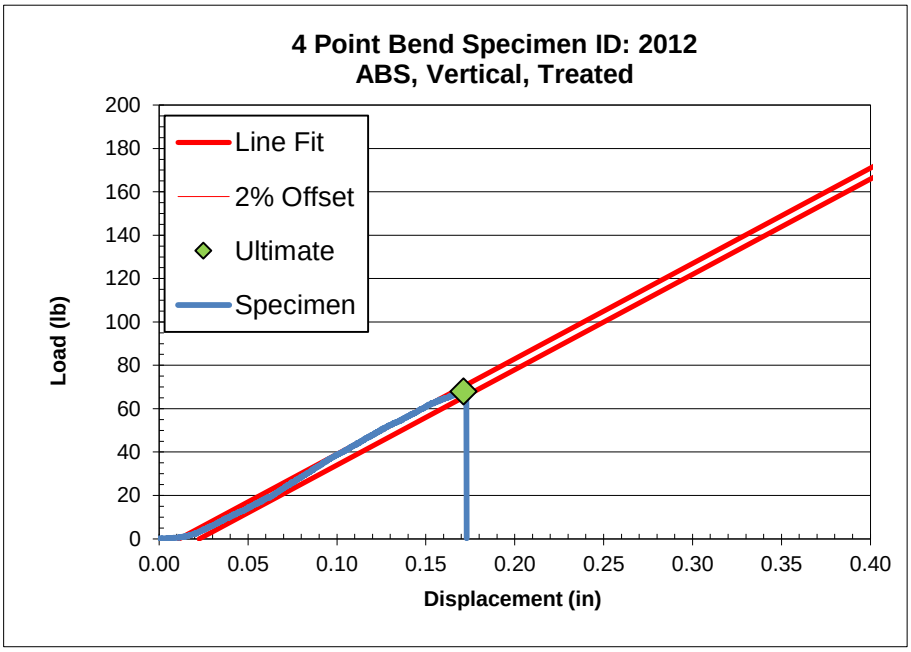


2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	435.5	lb/in
Ultimate Load:	58.40	lb
Displacement at Ultimate:	0.1340	in
Ultimate Bending Stress:	3191.0	psi



2% Yield:	N/A	lb
2% Yield Stress:	N/A	psi
Stiffness:	439.6	lb/in
Ultimate Load:	67.97	lb
Displacement at Ultimate:	0.1600	in
Ultimate Bending Stress:	3623.6	psi