Team 10: Shaft Deflection Study

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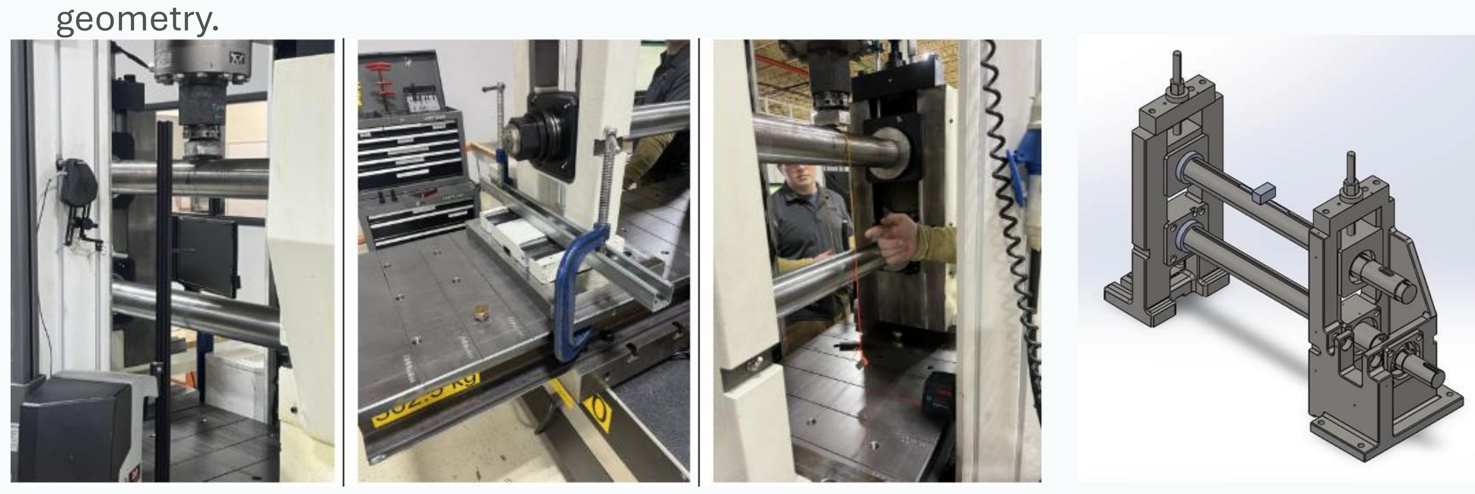
GVSU Senior Engineering • Shape Corp. Roll Form Shaft Deflection

Project Setup & First Round

Objective: validate a CAE model and build an Excel-based shaft-size predictor for future roll-form layouts.

Problem: shaft bending can move the rollers, increase wear, and change final part geometry.



Original spacing tests and simplified FEA CAD

Initial physical test

- 3 in. shaft with inboard/outboard stands
- 16, 20, and 24 in. roll spacing
- 12 o'clock and 3 o'clock keyway comparisons
- Instron moved until 2 mm crosshead displacement
- Baseline load: about 60–65 kN

What the first model showed

FEA run	Defl.	Error	Takeaway
Bonded	0.40	74%	Too stiff
Friction	1.04	42%	Contacts matter
Split	1.55	17%	Closest path

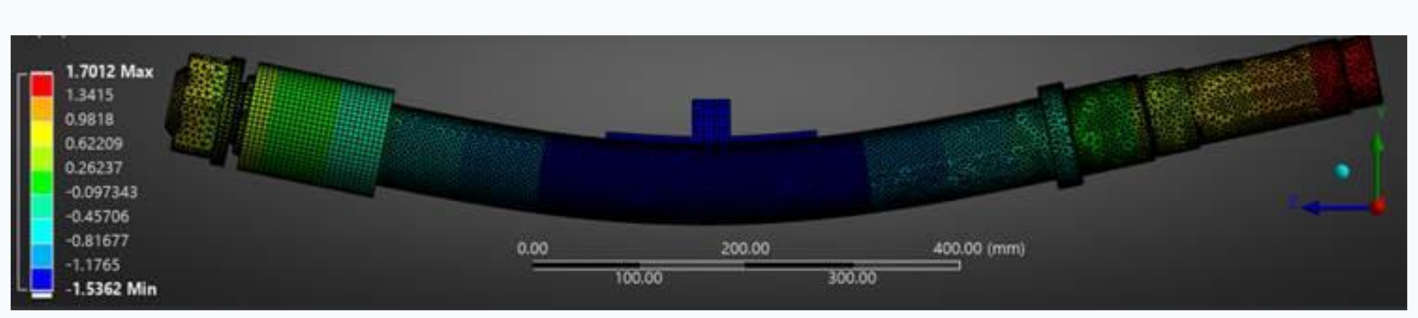
The split study localized most movement to the shaft, not the stand.

99.3%
structural deflection came from shaft

0.1105
mm avg setup compliance

17%
gap to old 2 mm crosshead value

Decision: do not build a reinforced stand first. Improve test accuracy, then use shaft sizing as the main design path.

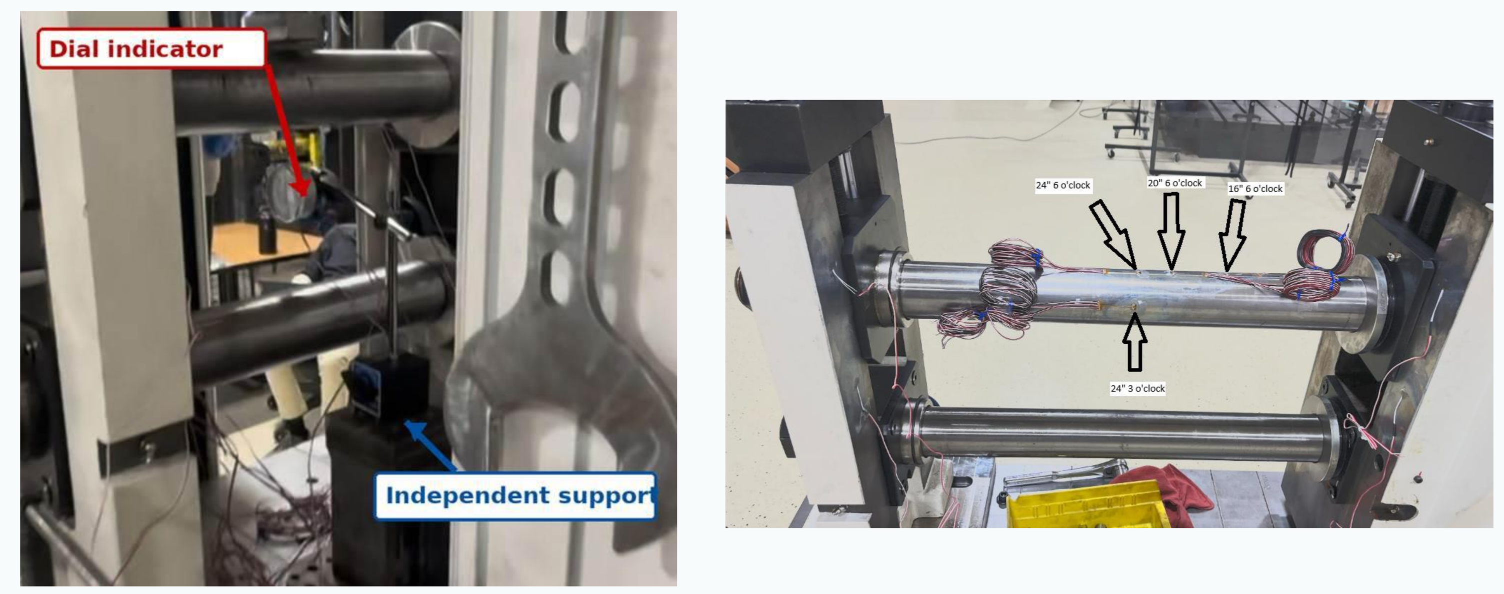


Split shaft model: bending dominated by the shaft

Why We Re-Tested / Refined Data

Reason for continued testing

The original "2 mm" was the Instron crosshead value, so it also included machine compliance, fixture settling, stand movement, and shaft bending.



Independent dial indicator + rosette strain gauges

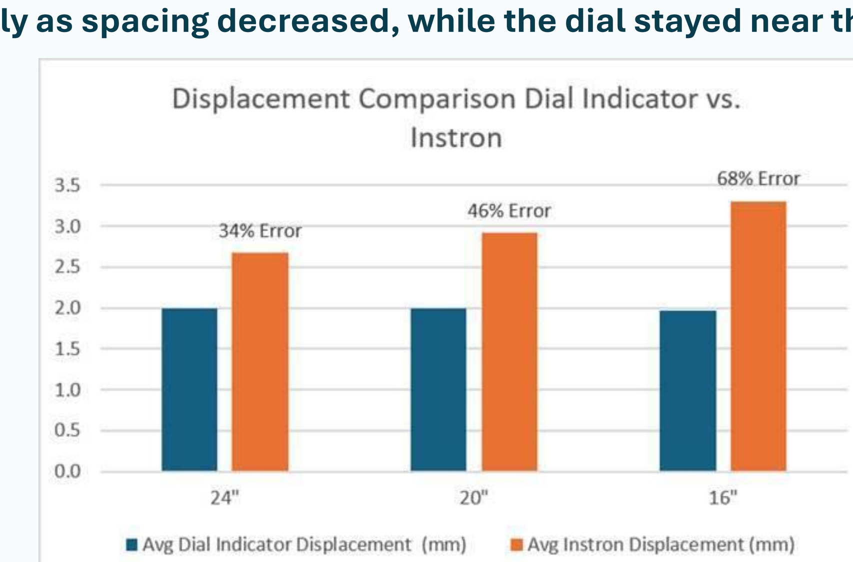
Updated test method

- Same 3 in. shaft and stands
- Load applied at shaft center
- Stop at ≈2 mm direct dial-indicator movement
- Record load, Instron displacement, dial displacement, shaft strain, and stand strain

Refined experimental summary

Span	Load	Instron	Dial	Main strain
24 in.	82	2.67	2.00	1390 με
20 in.	121	2.92	1.99	1775 με
16 in.	185	3.31	1.97	2173 με

Load rose sharply as spacing decreased, while the dial stayed near the 2 mm target.



Instron reported higher displacement than direct shaft measurement

Key learning: the old test overestimated shaft movement, especially as load increased.

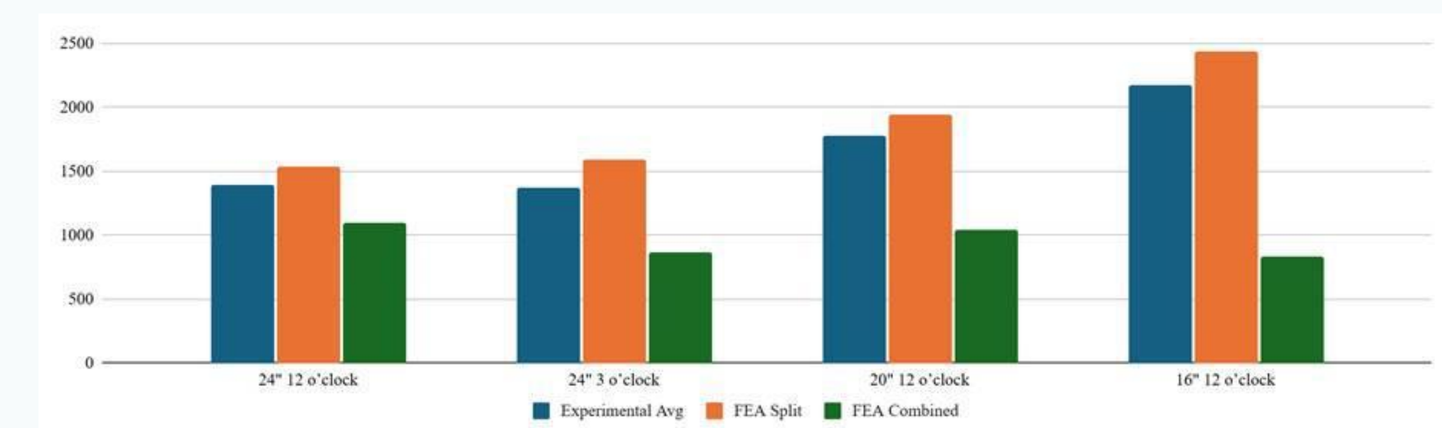
FEA Correlation & Predictive Model

5.5%
avg split FEA error with uncertainty

61%
4 in. deflection reduction

0.2 mm
predictor deflection limit

FEA reverification



Split FEA followed measured shaft-strain trend better than combined FEA

Raw average error: split ≈6.9% vs. combined ≈40.3%. Stand gauges showed load-transfer trends but were not used as the primary validation value.

Predictive model logic

Inputs: roll spacing + forming force from the rigid-shaft simulation.
Output: smallest shaft size that keeps predicted deflection at or below 0.2 mm.

Calculation: Predicted Deflection = 0.2 mm × (Applied Forming Force(Frd) ÷ Capacity (F0.2))

FEA capacity table, F0.2 (kN)

Span	2 in.	3 in.	4 in.
12	8.8	38.5	N/A
16	4.5	20.6	N/A
20	2.6	12.3	34.2
24	N/A	8.8	22.9
28	N/A	N/A	15.3

3 in. vs. 4 in. shaft simulation

Size	Defl.	Strain	Force for 2 mm
3 in.	1.885	1464 με	88.6 kN
4 in.	0.731	644 με	224.4 kN

Recommendation: use the split shaft model as the predictor basis; shaft diameter and roll spacing are the two main design levers.

1 Baseline test
3 in. shaft / Instron crosshead

2 Model issue
Combined FEA too stiff

3 Refined test
Dial indicator + strain gauges

4 Predictor
Recommend shaft size + deflection