

SPLICE RESEARCH
Progress Report
YIELD-LINE ANALYSIS OF END-PLATE CONNECTIONS
WITH BOLT FORCE PREDICTIONS
-- ADDENDUM --

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PREFACE

This ADDENDUM contains the experimental data for the six two row, four bolts at the tension flange, flush end-plate tests used to verify the analytical predictions developed in the report. The designation F2-5/8-1/2-16 is to be interpreted as follows: F2, two bolt row flush end-plate connection; 5/8, 5/8 in. diameter A325 bolts; 1/2, 1/2 in. thick end-plate; and 16, 16 in. deep beam. Other test designations are to be interpreted in the same fashion.

-- ADDENDUM --

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APPENDIX C

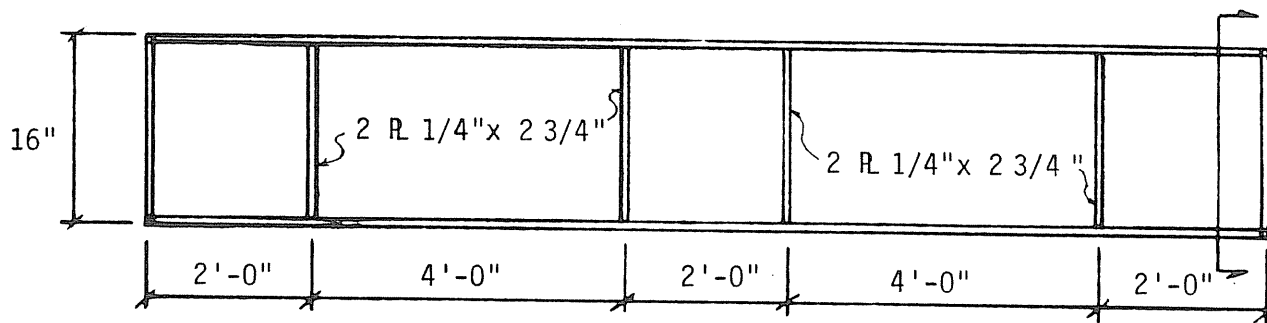
F2-5/8-1/2-16 TEST RESULTS

MBMA TEST SUMMARY

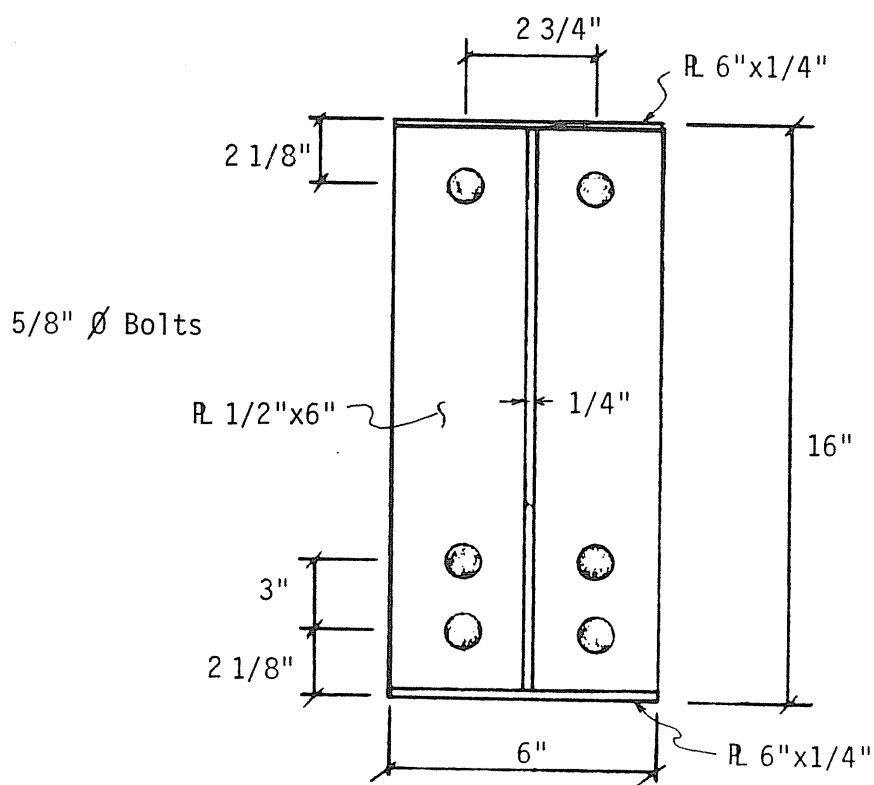
Project: MBMA Splice Connections
Test No.: F2-5/8-1/2-16
Test Date: 8/25-83
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 5/8 in. Plate Thickness: 1/2 in.
Beam Depth: 16 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 263.6 in.⁴
Pretension Force: 19 kips
Failure Load: 36 kips (108 ft. - kips)
Failure Mode: Bolt fracture
Predicted Failure Loads:
Method: Yield-line theory Load: 36.4 kips (109.1 ft. kips)
Method: _____ Load: _____
Maximum Displacements:
Vertical: 3.37 in.
Horizontal top flange: 0.144 in.
Horizontal bottom flange: 0.172 in.
Maximum plate separation: East: 0.0 Centerline: 0.166 in. West: 0.153 in.

Discussion:

- Maximum load applied was 36.0 kips resulting in a moment of 108 ft. - kips at the end-plate.
- Failure was due to bolt fracture at a load of 36.0 kips.
- Vertical displacement was close to theoretical up to a moment of 72 ft. - kips. The curve started to lean over at this load level.
- Plate separation was close to theoretical up to a moment of 68 ft. - kips at which point the curve started to lean over.
- Bolt forces exceed the bolt proof load at a load of 68 ft. - kips.



a) Elevation



b) End Plate

Figure C.1 Test Specimen Geometry, Test F2-5/8-1/2-16

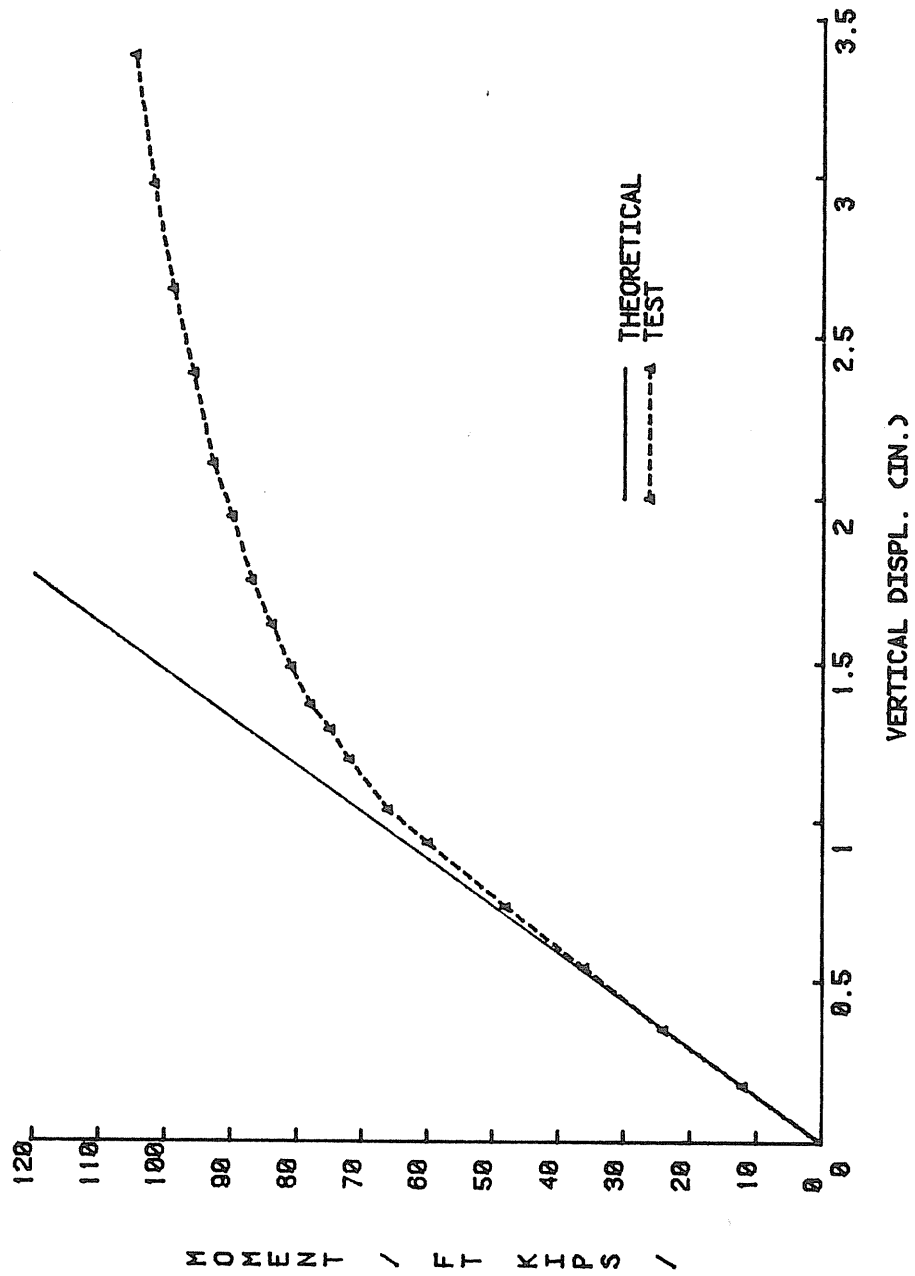


Figure C.2 Moment vs. Vertical Displacement, Test F2-5/8-1/2-16

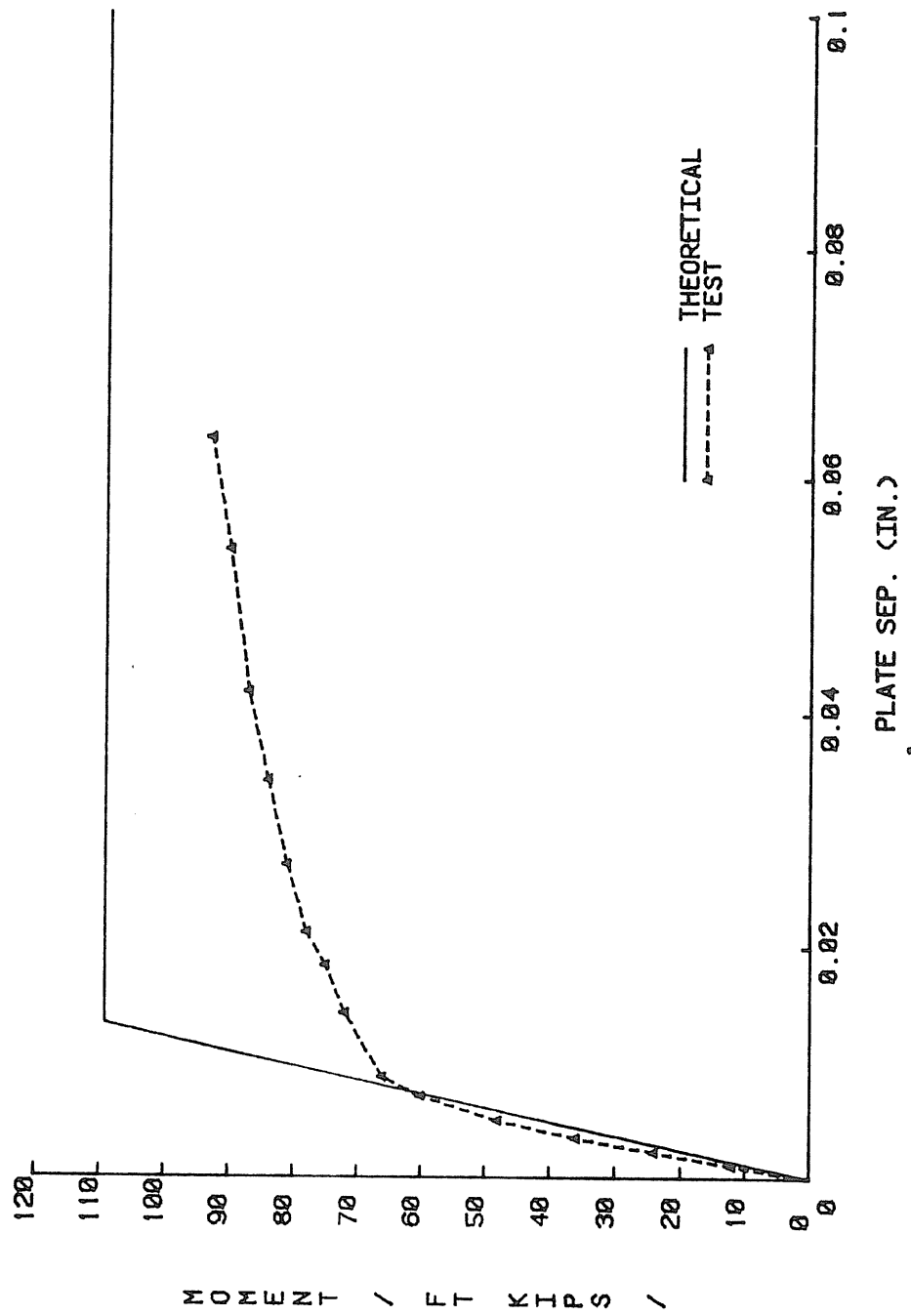


Figure C.3 Moment vs. Plate Separation, Test F2-5/8-1/2-16

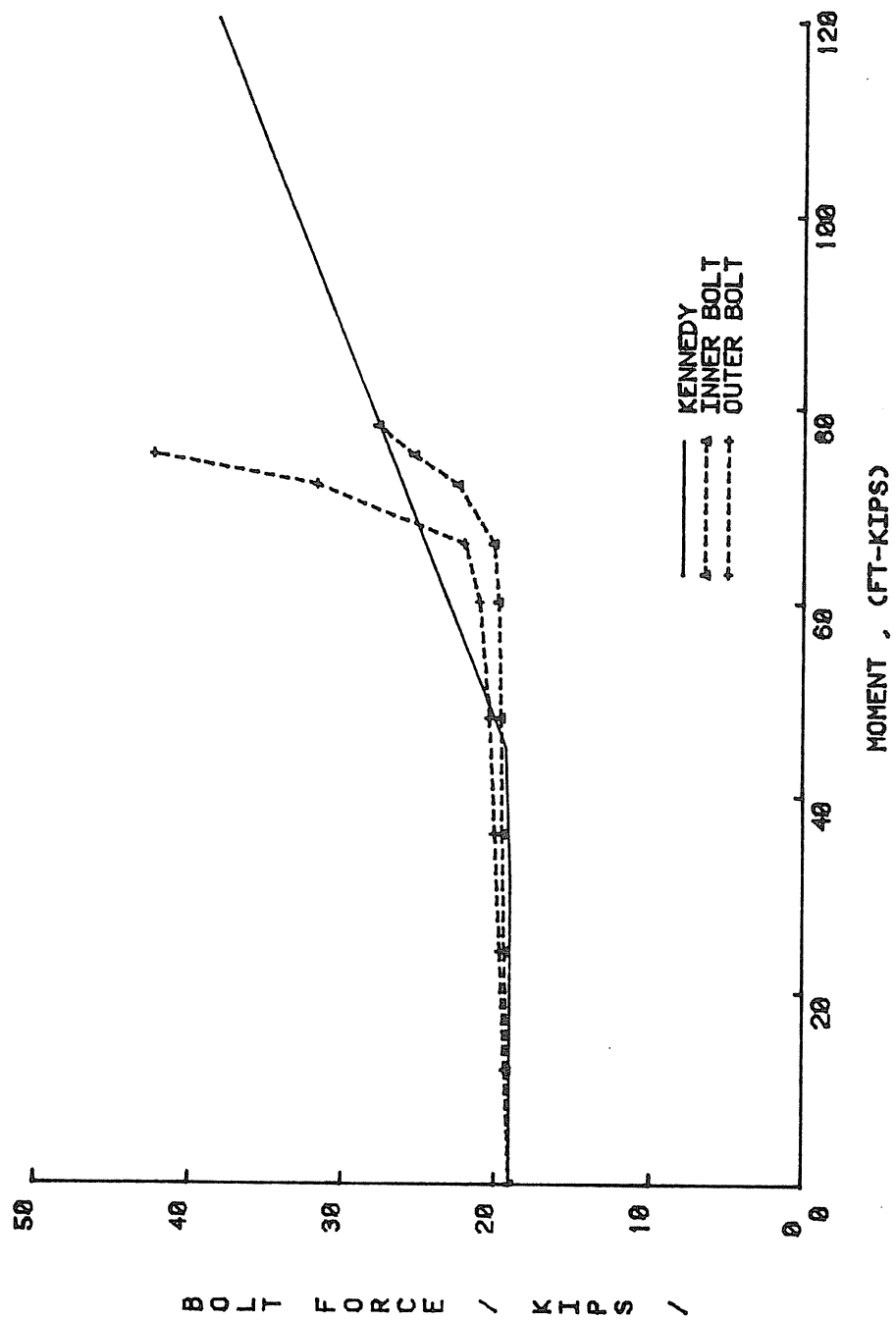


Figure C.4 Bolt Force vs. Moment, Test F2-5/8-1/2-16

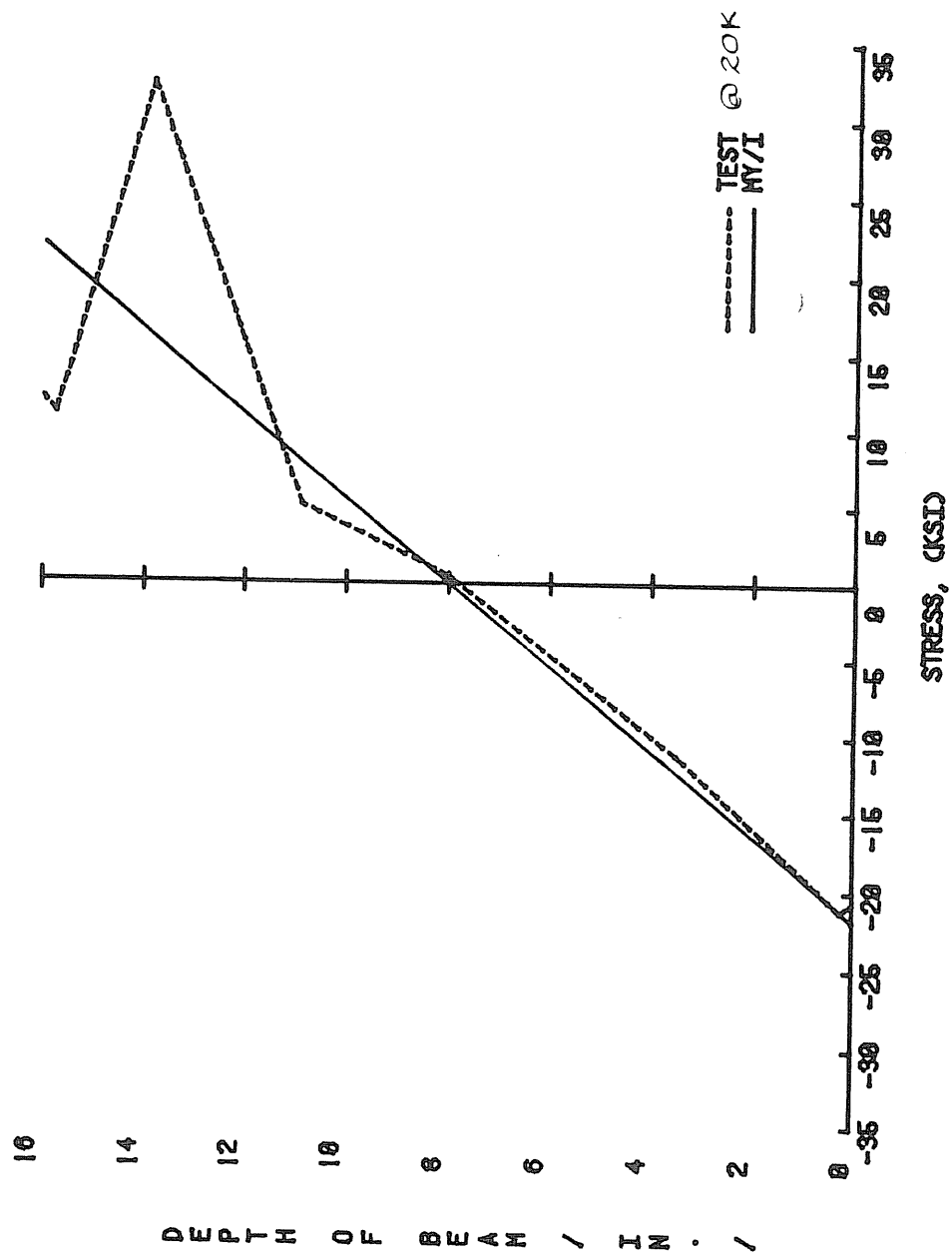


Figure C.5 Stress Distribution 2 in. from End-Plate at 20 kips,
Test F2-5/8-1/2-16

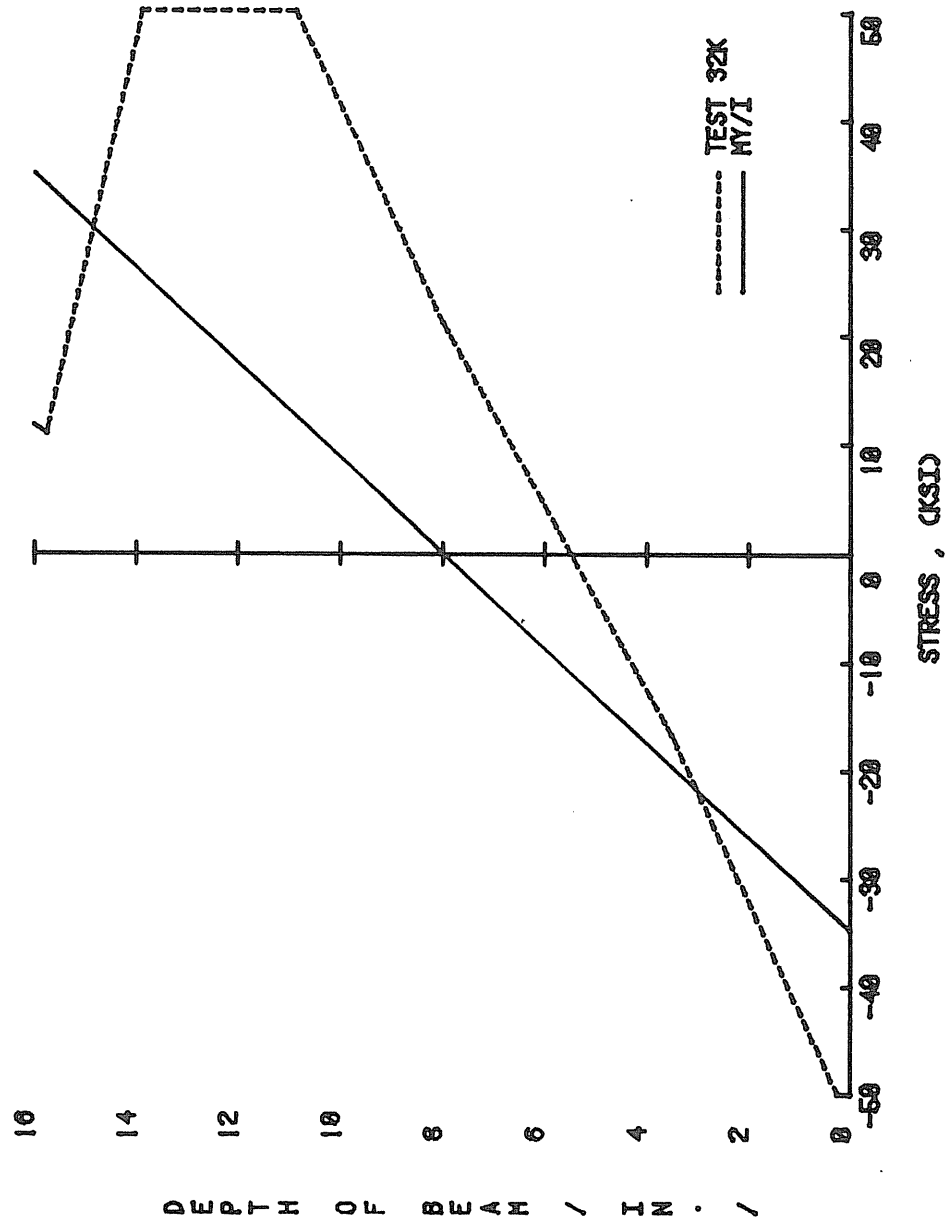


Figure C.6 Stress Distribution 2 in. from End-Plate at 32 kips,
Test F2-5/8-1/2-16

APPENDIX D

F2-5/8-3/8-16 TEST RESULTS

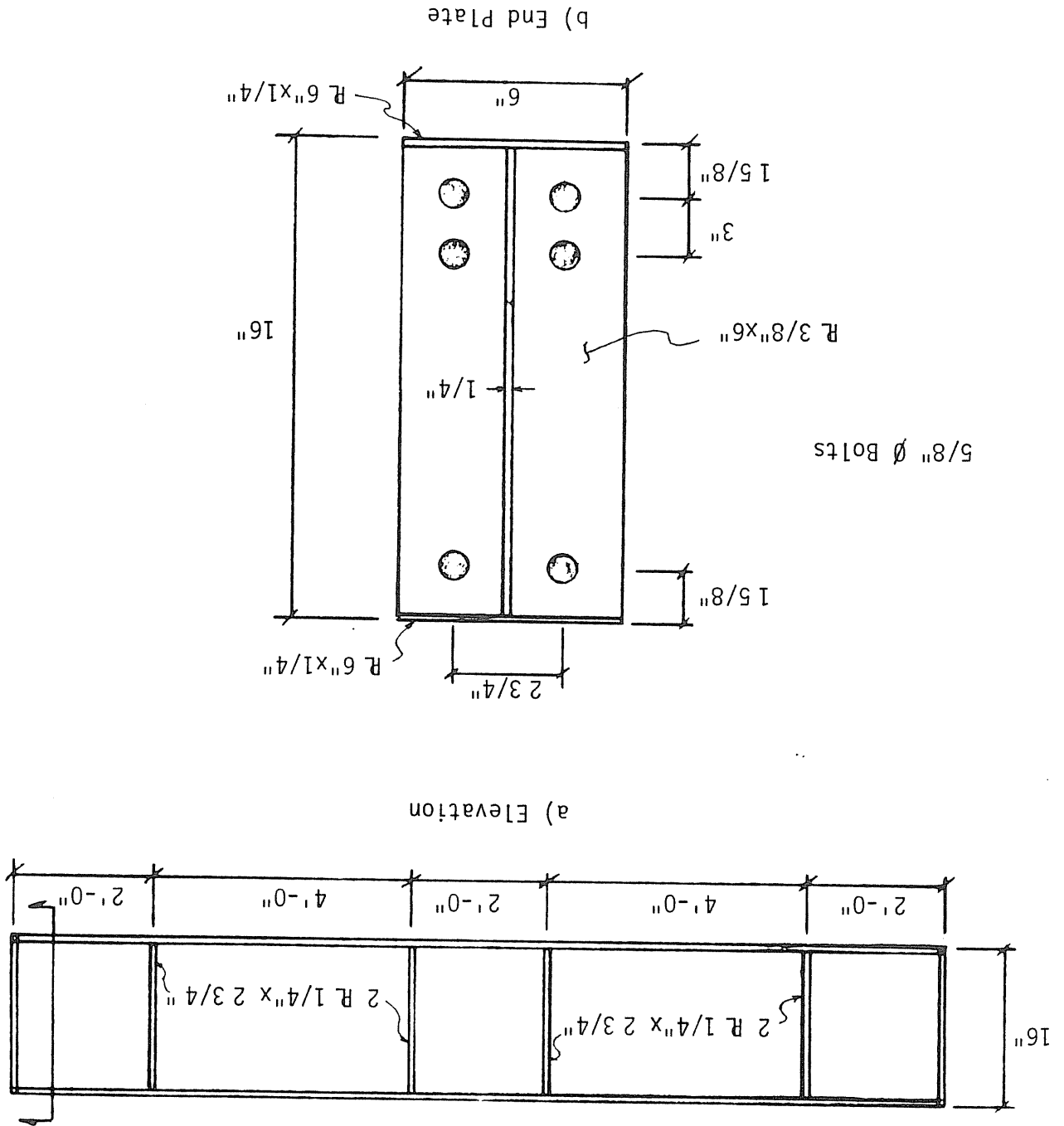
MBMA TEST SUMMARY

Project: MBMA Splice Connections
Test No.: F2-5/8-3/8-16
Test Date: 9/16/83
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 5/8 in. Plate Thickness: 3/8 in.
Beam Depth: 16 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 263.6 in.⁴
Pretension Force: 19 kips
Failure Load: 29.5 kips (85.5 ft. - kips)
Failure Mode: Yielding of end-plate
Predicted Failure Loads:
Method: Yield-line theory Load: 27.2 kips (81.6 ft. - kips)
Method: Load:
Maximum Displacements:
Vertical: 3.79 in.
Horizontal top flange: 0.240 in.
Horizontal bottom flange: 0.226 in.
Maximum plate separation: East: 0.0 Centerline: 0.09 in. West: 0.0

Discussion:

- Maximum load applied was 29.5 kips resulting in a moment of 85.5 ft. - kips at the end-plate.
- Failure was due to yielding of end-plate and excessive plate separation.
- The calipers used to measure the plate separation were taken off at a load of 20 kips (60 ft. - kips) so they won't be damaged.
- Vertical displacement was close to theoretical up to a moment of 36 ft. - kips. The curve started to lean over at this point.
- Plate separation was close to theoretical up to a moment of 27 ft. - kips at which point the curve started to lean over.
- Bolt forces exceeded the bolt proof load at a moment of 39 ft. - kips.

Figure D.1 Test Specimen Geometry, Test F2-5/8-3/8-16



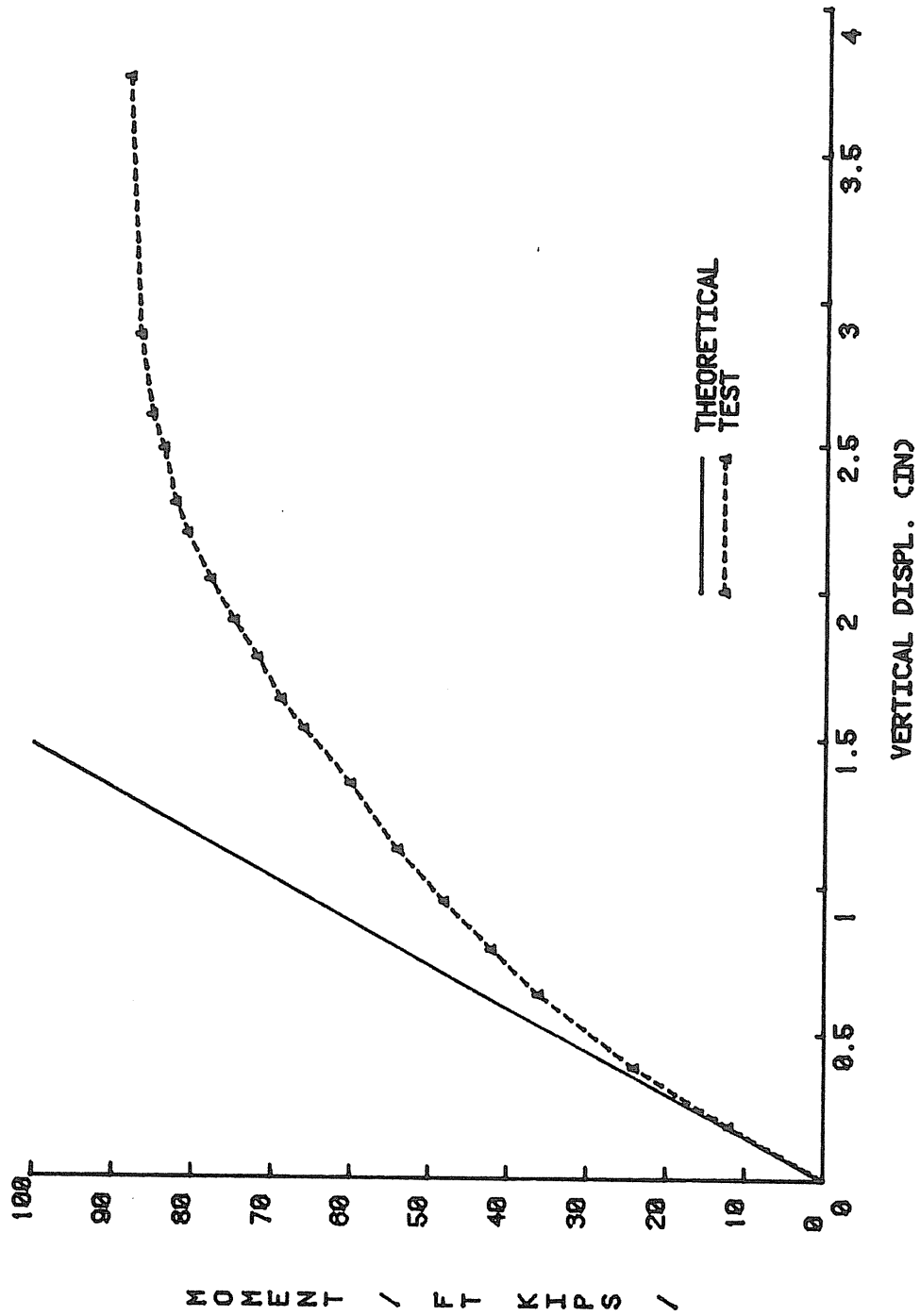


Figure D.2 Moment vs. Vertical Displacement, Test F2-5/8-3/8-16

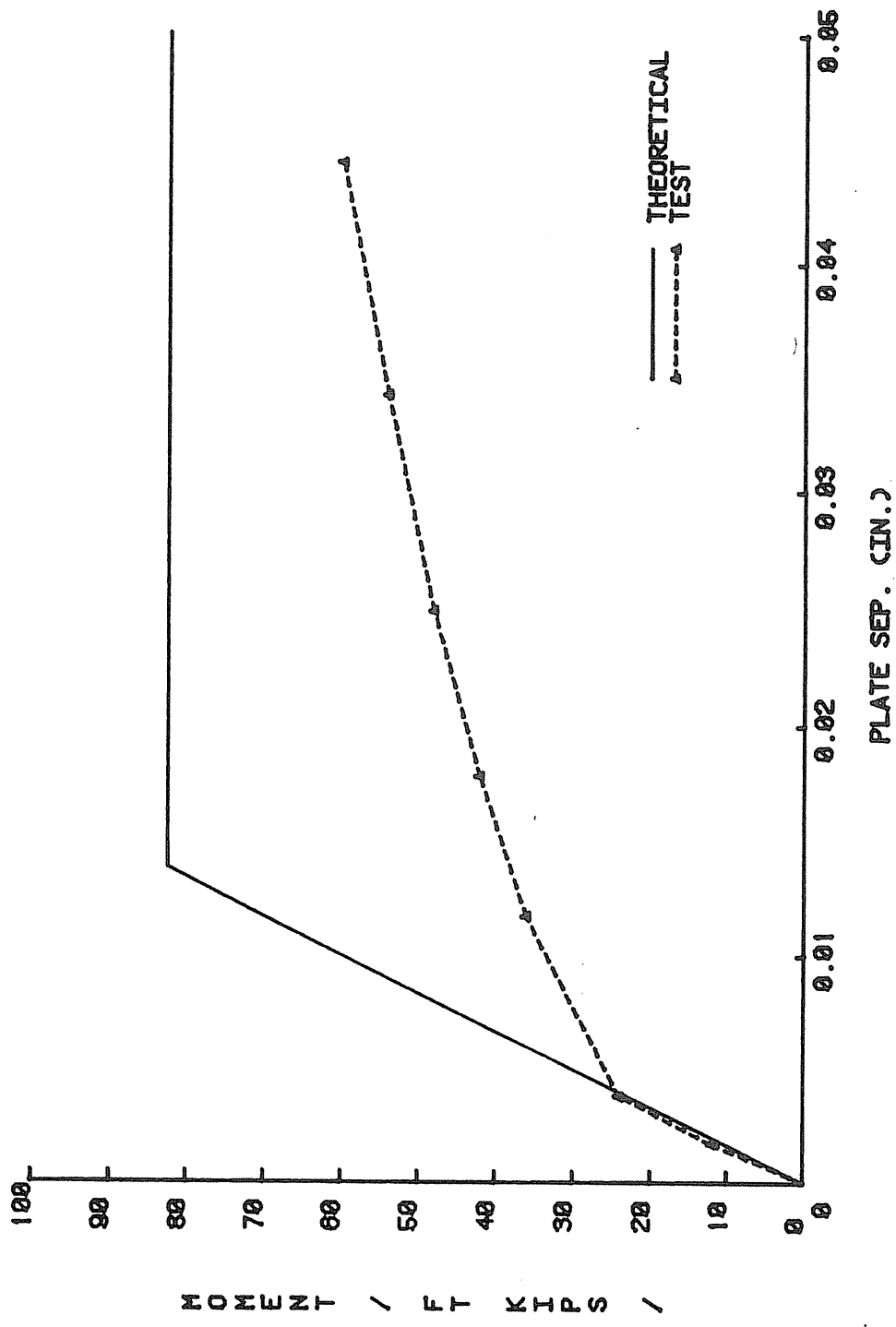


Figure D.3 Moment vs. Plate Separation, Test F2-5/8-3/8-16

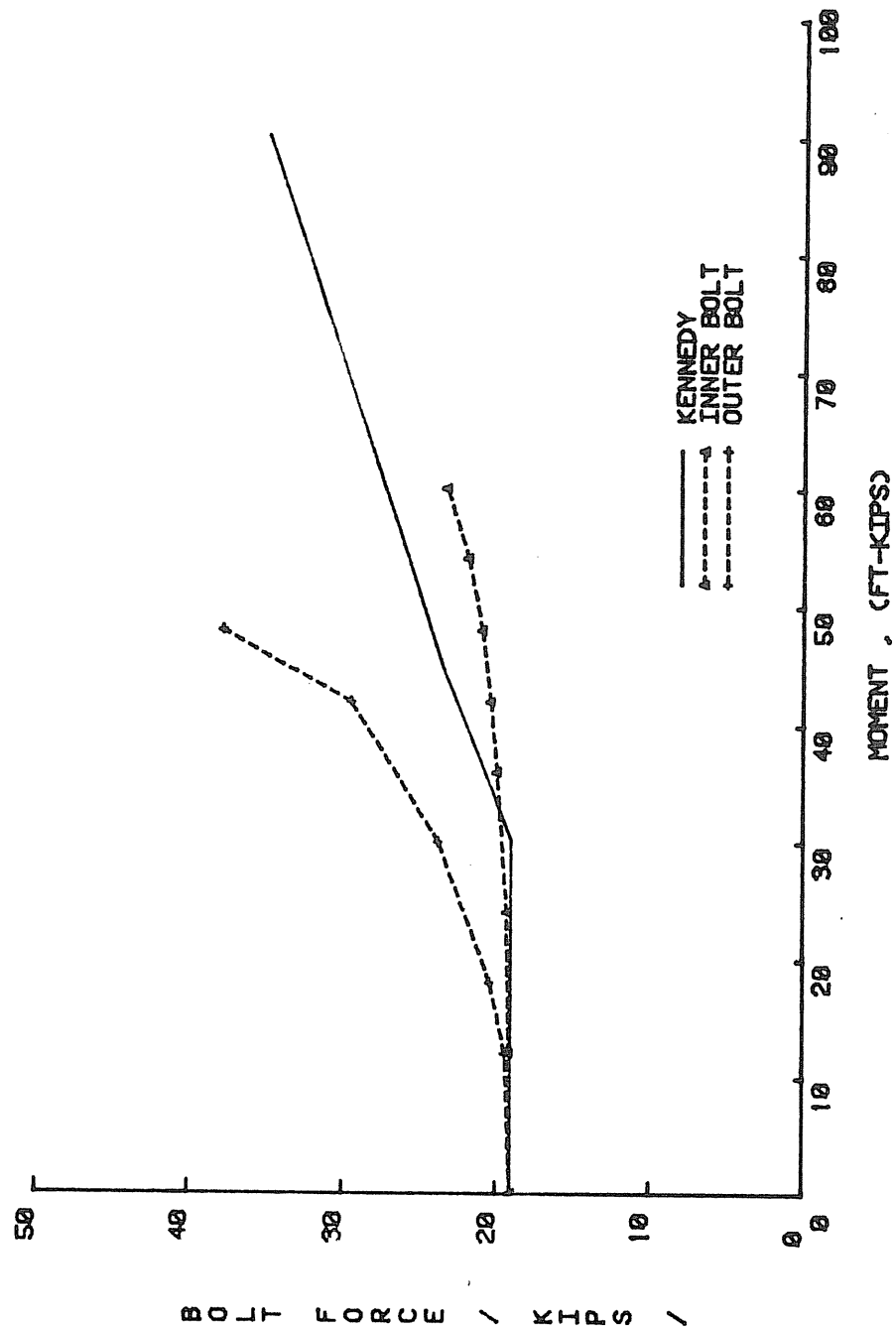


Figure D.4 Bolt Force vs. Moment, Test F2-5/8-3/8-16

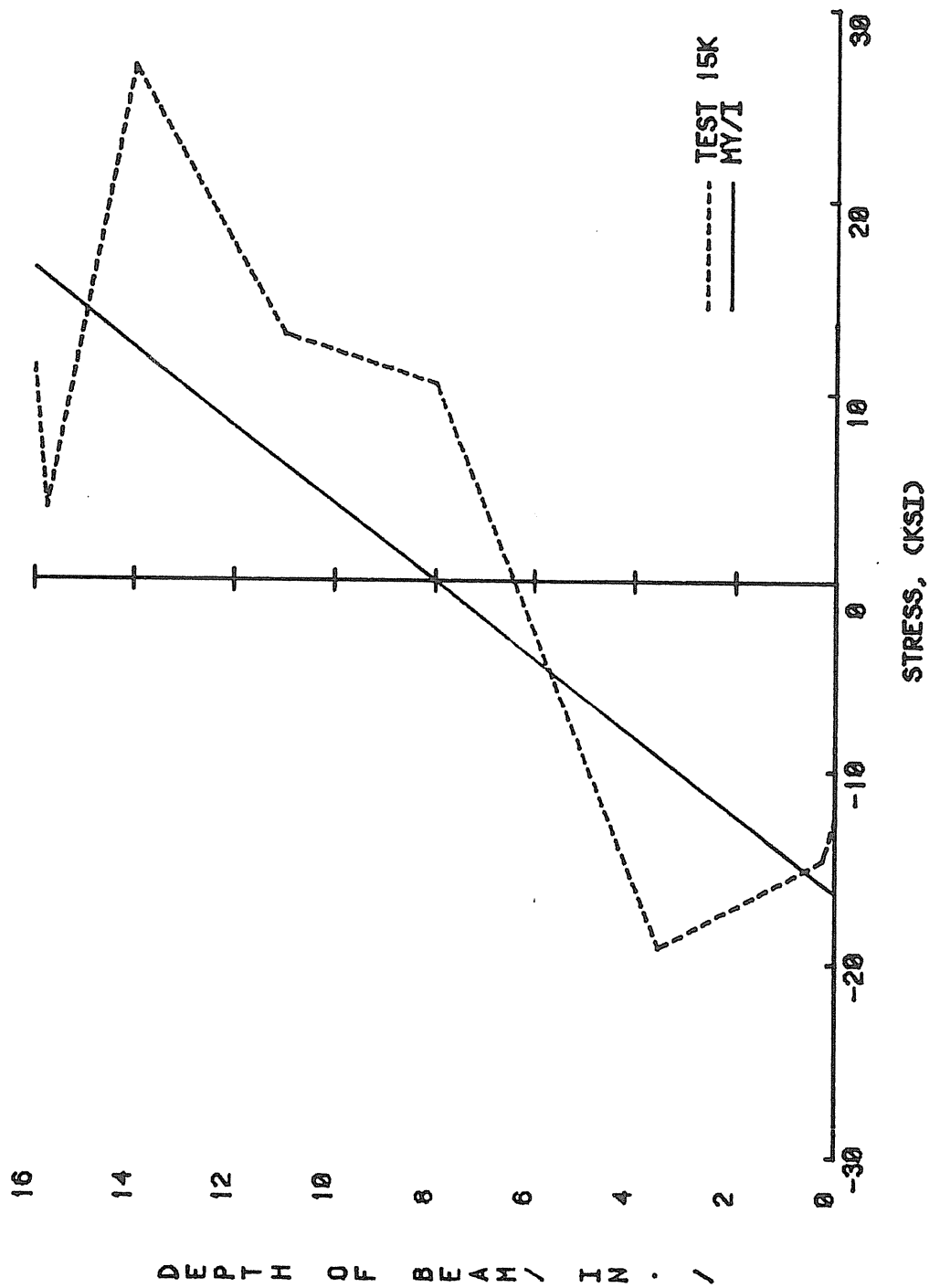


Figure D.5 Stress Distribution 2 in. from End-Plate at 15 kips,
Test F2-5/8-3/8-16

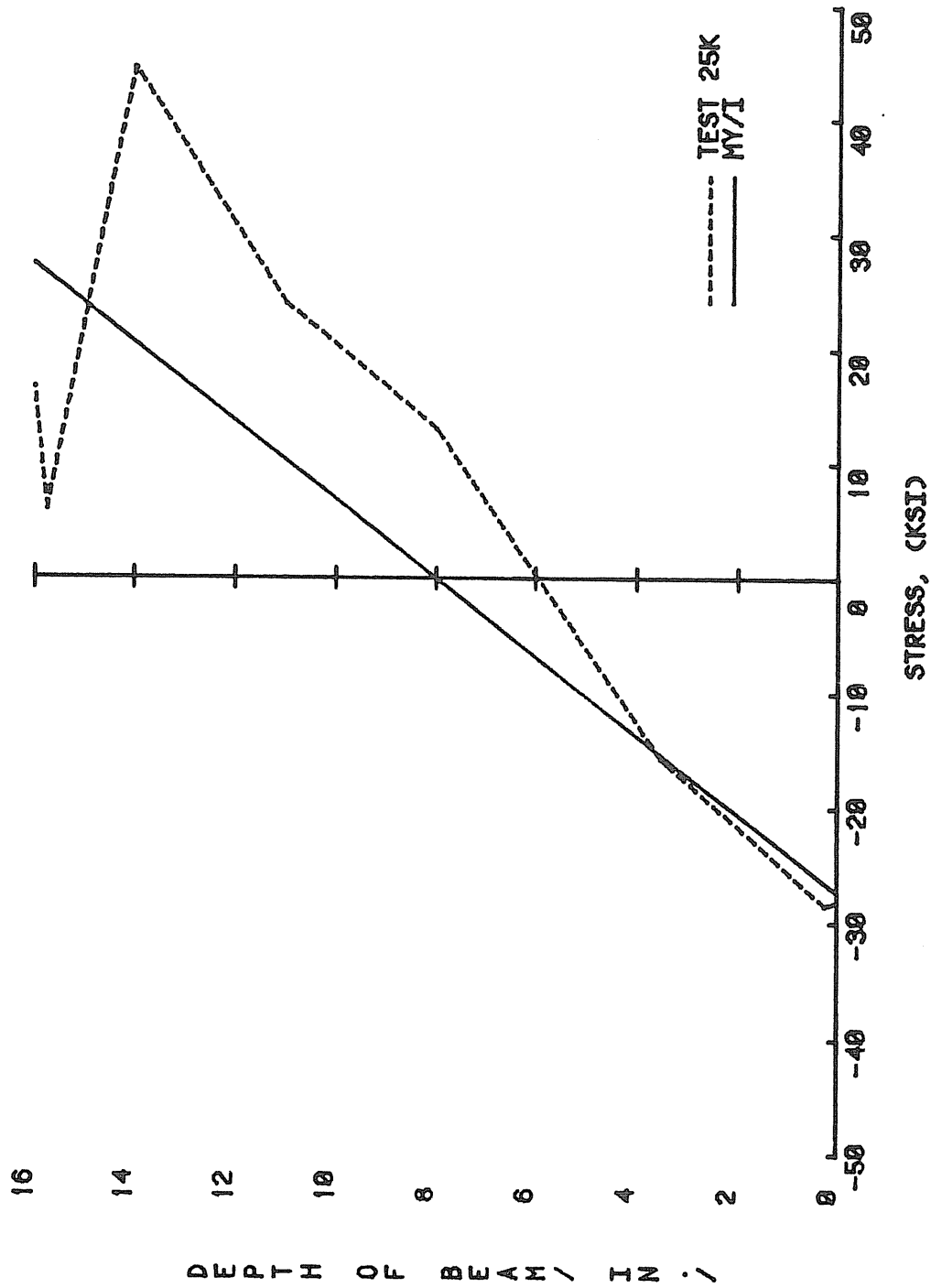


Figure D.6 Stress Distribution 2 in. from End-Plate at 25 kips,
Test F2-5/8-3/8-16

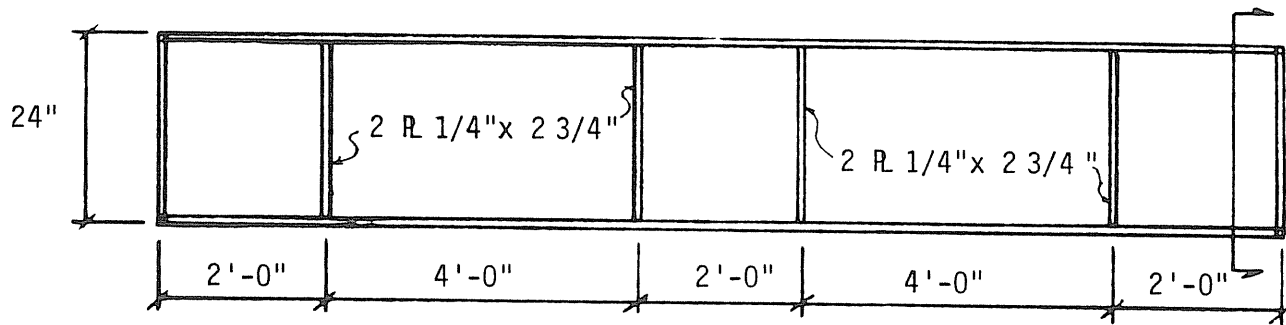
APPENDIX E
F2-3/4-1/2-24 TEST RESULTS

MBMA TEST SUMMARY

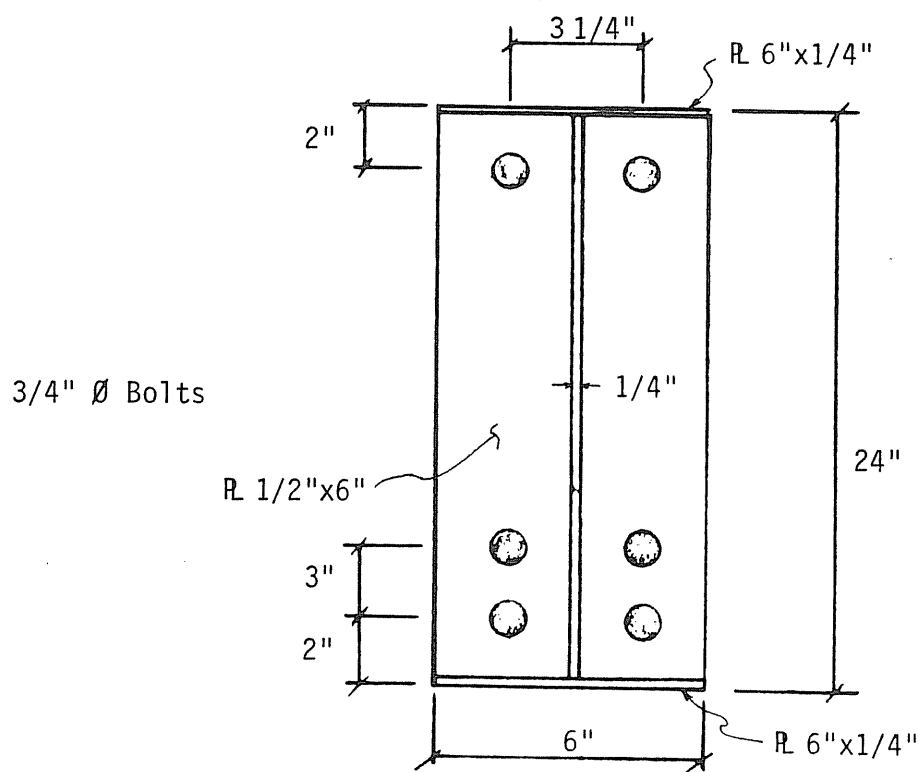
Project: MBMA Splice Connections
Test No.: F2-3/4-1/2-24
Test Date: 11/2/83
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 3/4 in. Plate Thickness: 1/2 in.
Beam Depth: 24 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 693.4 in.⁴
Pretension Force: 28 kips
Failure Load: 55 kips (171.8 ft. - kips)
Failure Mode: Yielding of end-plate
Predicted Failure Loads:
Method: Yield-line theory Load: 56.7 kips (177.3 ft. - kips)
Method: _____ Load: _____
Maximum Displacements:
Vertical: 1.240 in.
Horizontal top flange: 0.140 in.
Horizontal bottom flange: 0.150 in.
Maximum plate separation: East: 0.0 Centerline: 0.0630 in. West: 0.044 in.

Discussion:

- Maximum applied moment was 171.8 ft. - kips at the end-plate.
- Failure was due to yielding of end-plate.
- Vertical displacement was close to theoretical up to a moment of 140.0 ft. - kips at which point the curve started to lean over.
- Plate separation was close to theoretical up to a moment of 142.0 ft. - kips then the curve started to lean over.
- Bolt forces did not exceed the proof load.



a) Elevation



b) End Plate

Figure E.1 Test Specimen Geometry, Test F2-3/4-1/2-24

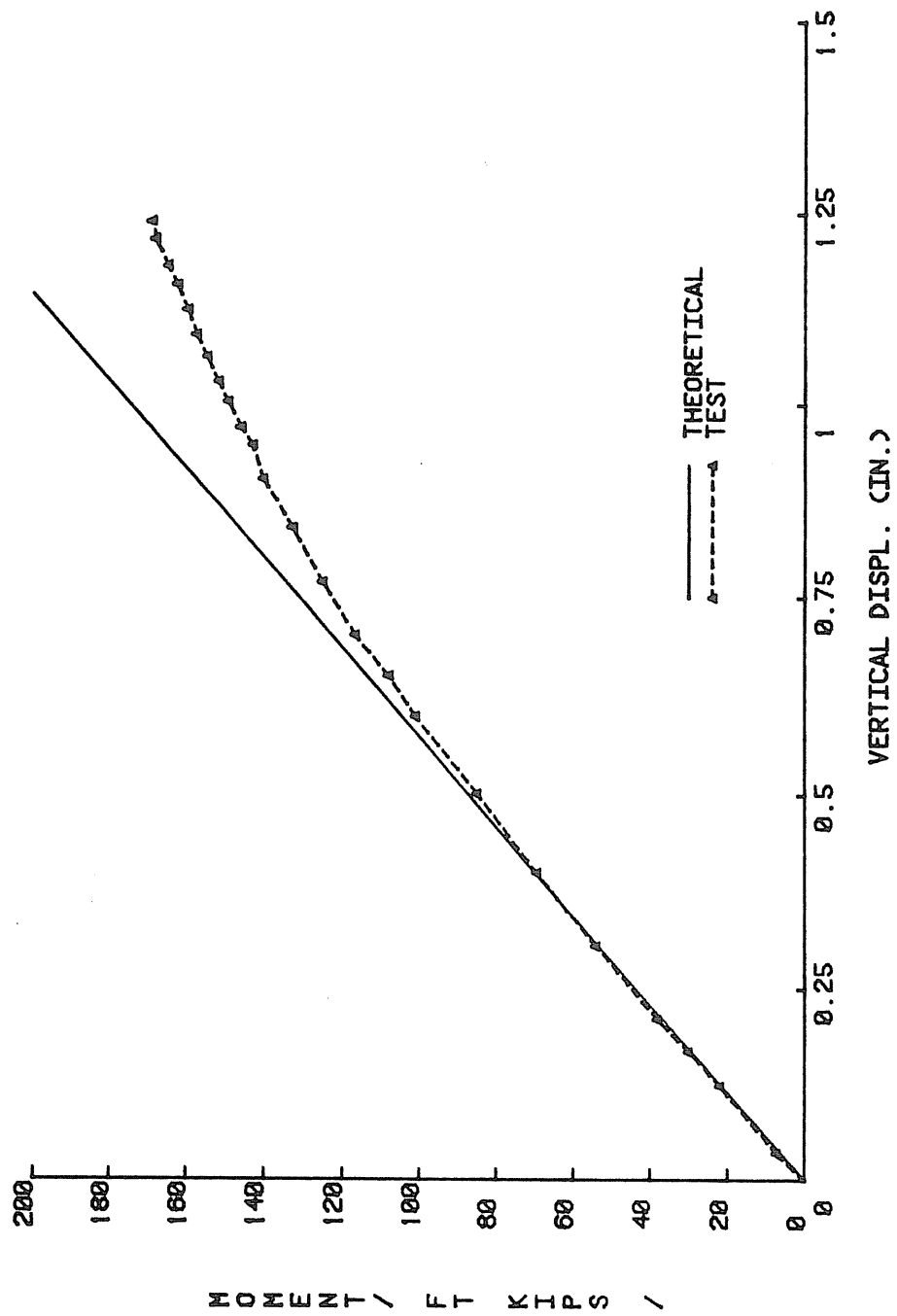


Figure E.2 Moment vs. Vertical Displacement, Test F2-3/4-1/2-24

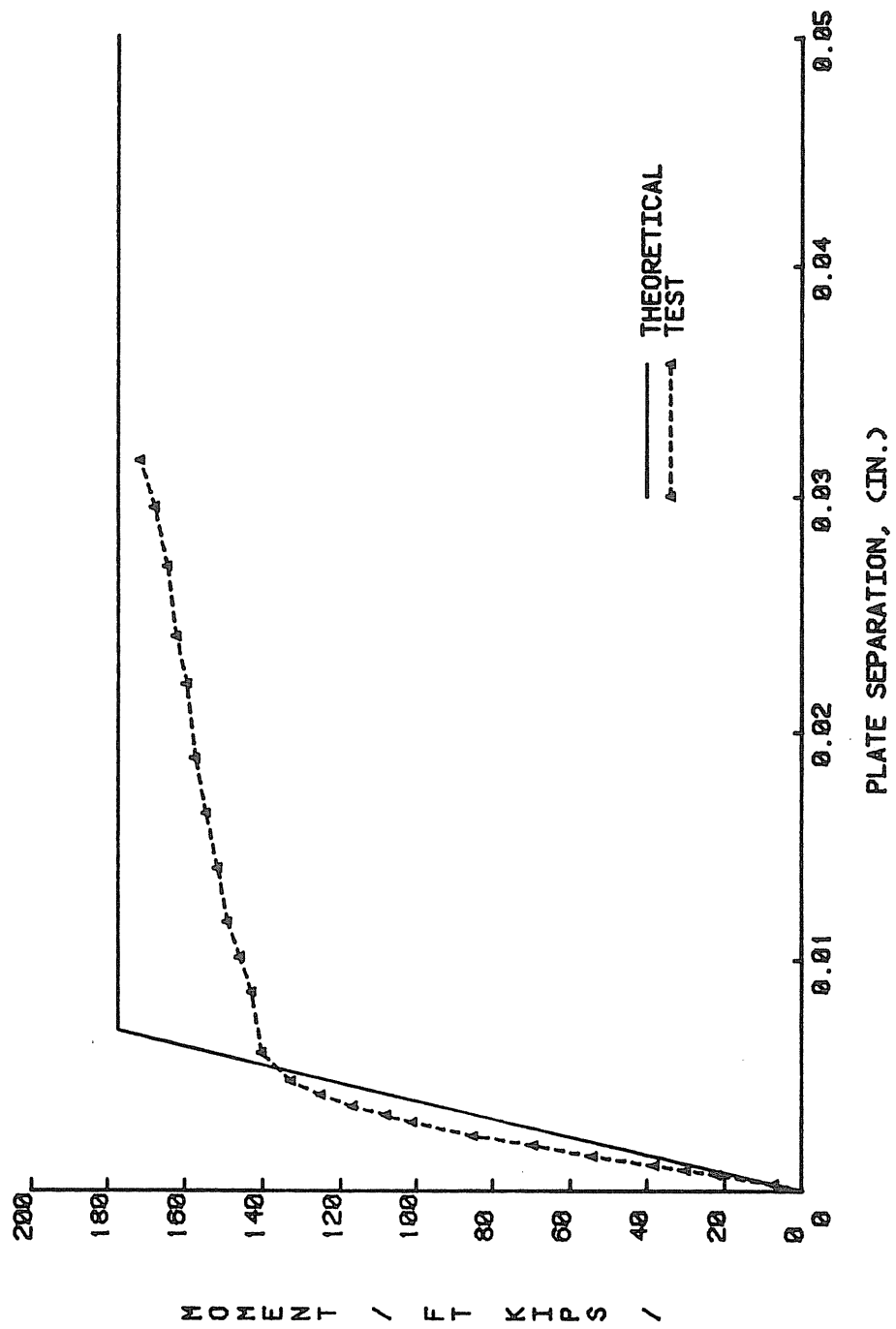


Figure E.3 Moment vs. Plate Separation, Test F2-3/4-1/2-24

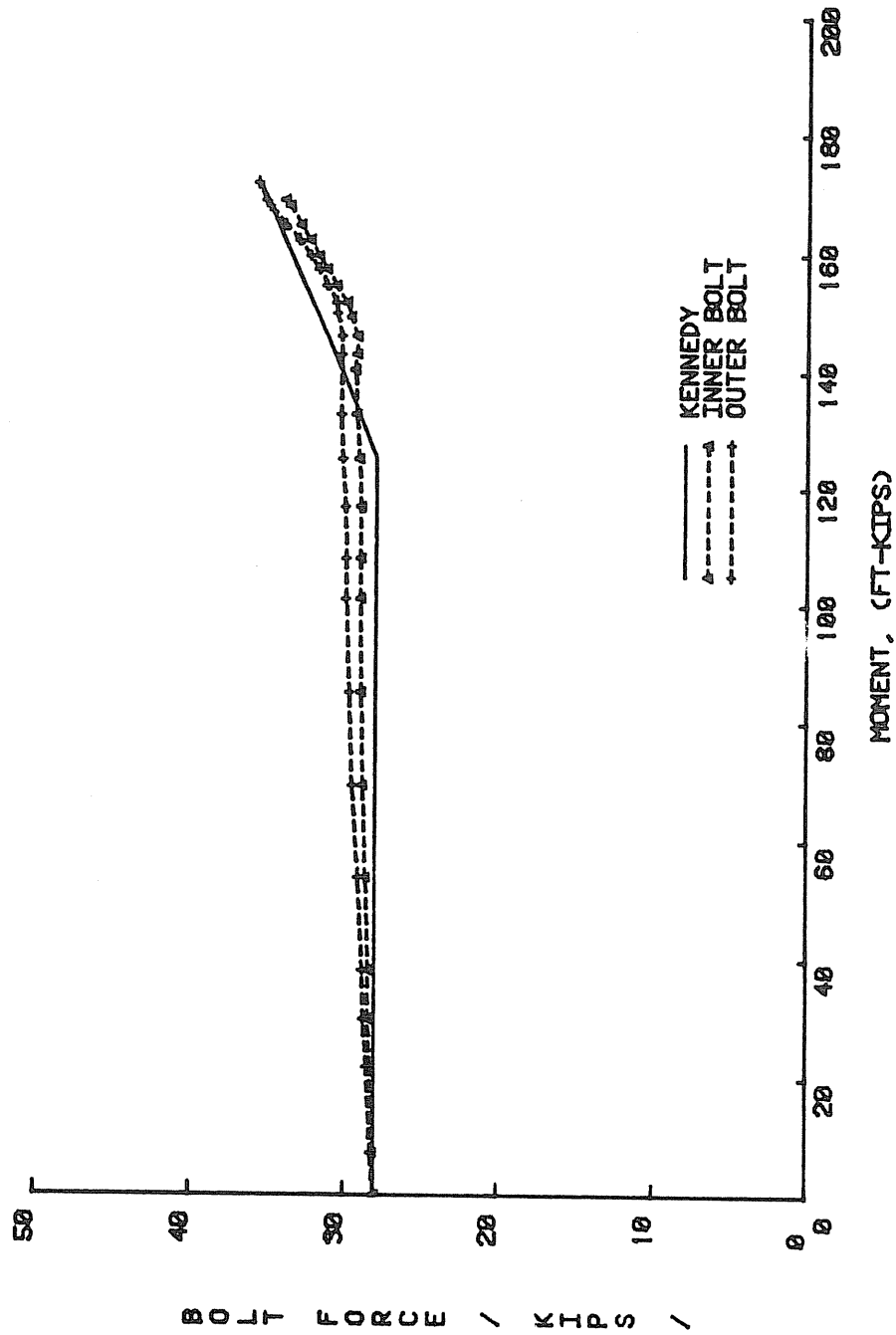


Figure E.4 Bolt Force vs. Moment, Test F2-3/4-1/2-24

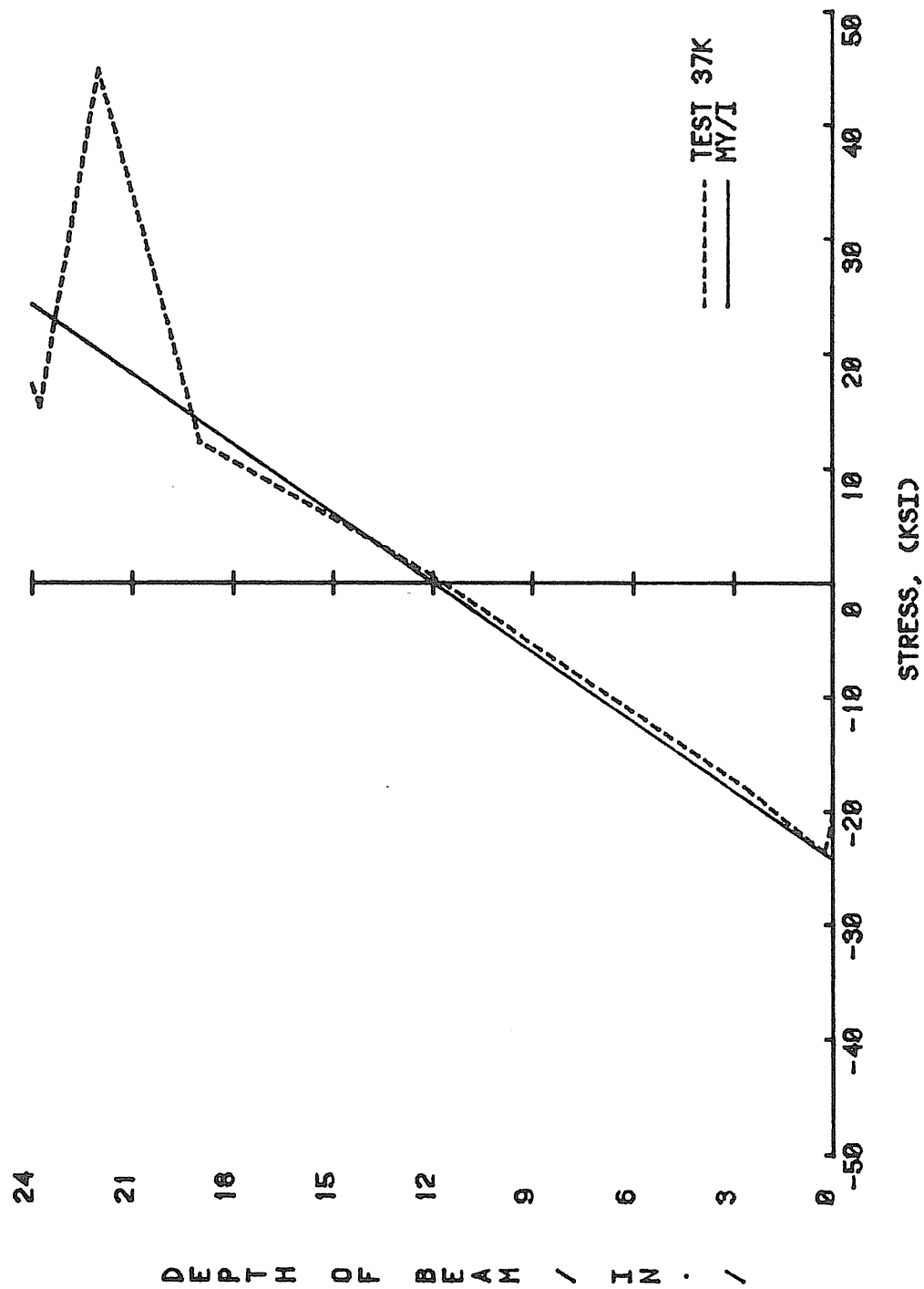


Figure E.5 Stress Distribution 2 in. from End-Plate at 37 kips,
Test F2-3/4-1/2-24

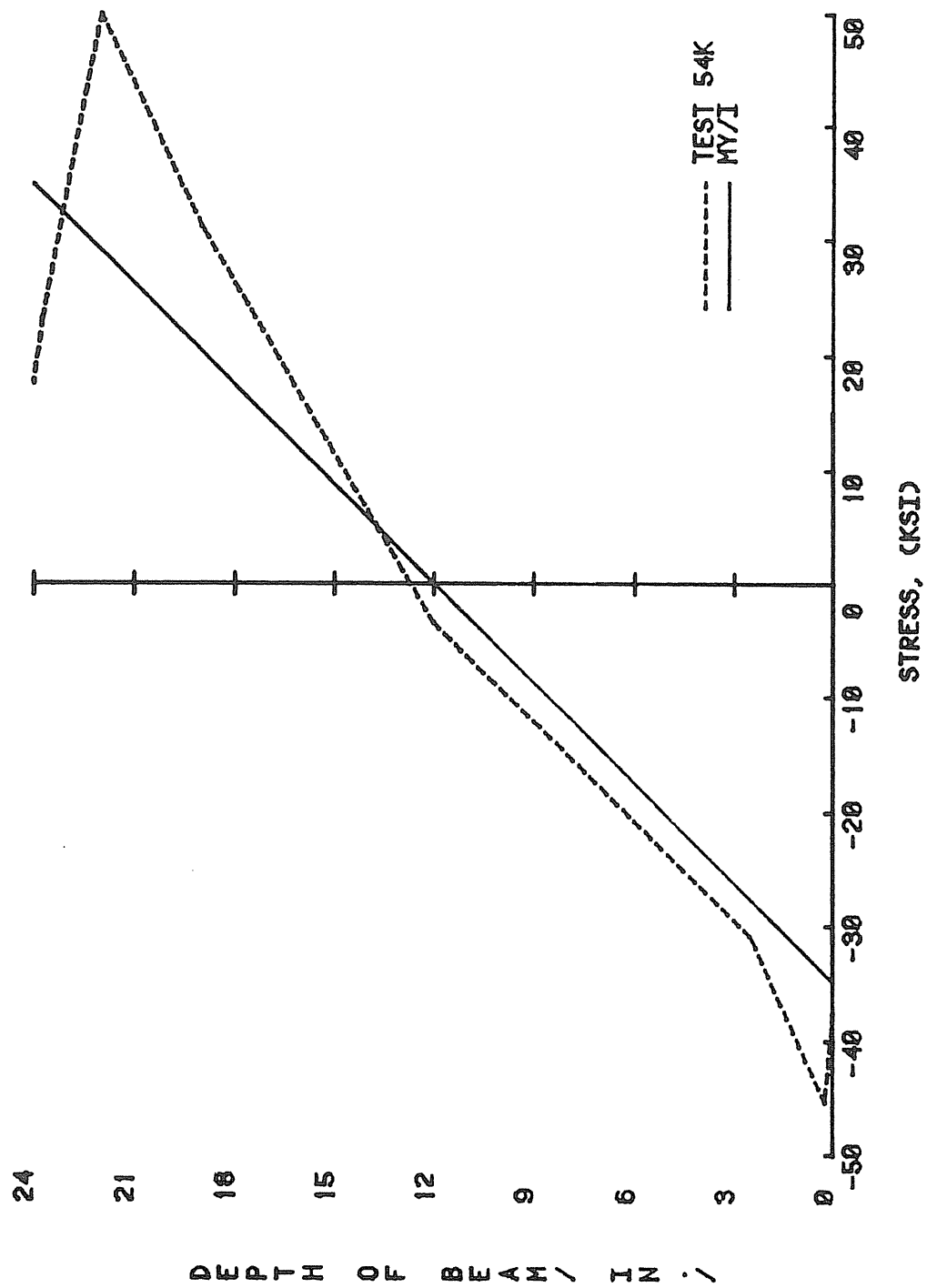


Figure E.6 Stress Distribution 2 in. from End-Plate at 54 kips,
Test F2-3/4-1/2-24

APPENDIX F

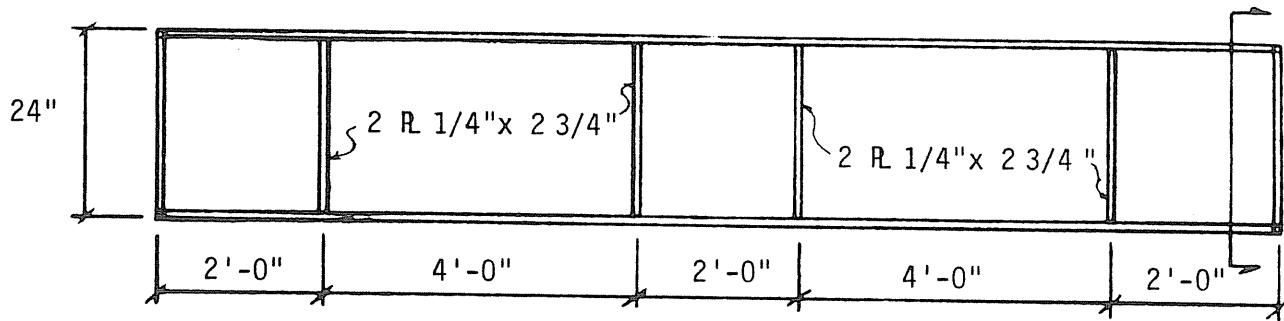
F2-3/4-3/8-24 TEST RESULTS

MBMA TEST SUMMARY

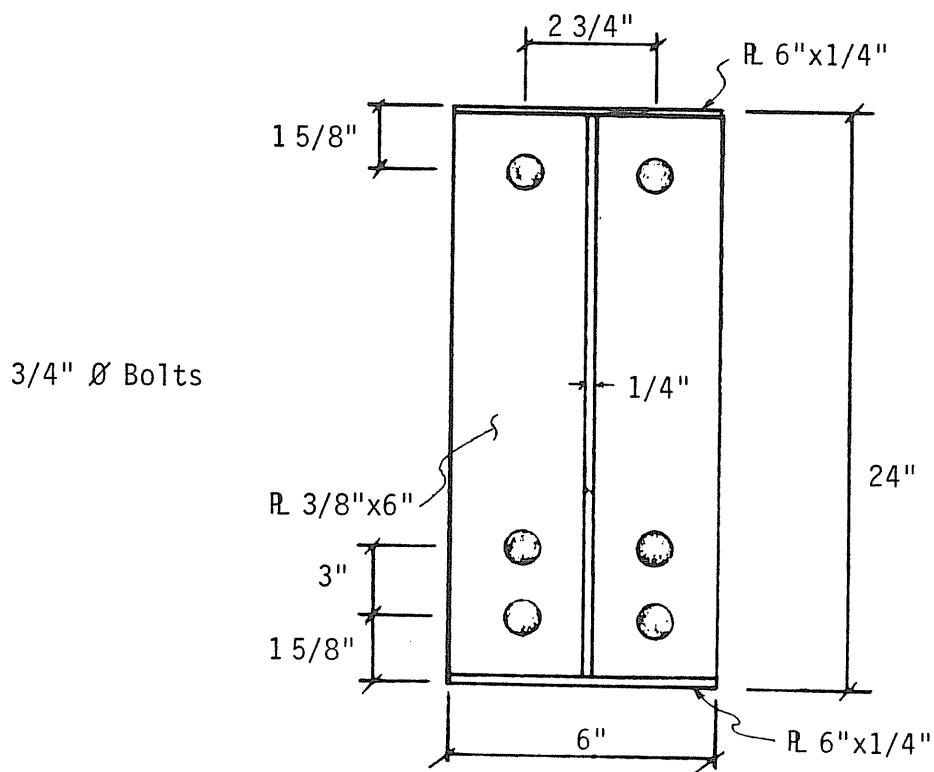
Project: MBMA Splice Connections
Test No.: F2-3/4-3/8-24
Test Date: 10/28/83
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 3/4 in. Plate Thickness: 3/8 in.
Beam Depth: 24 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 693.4 in.⁴
Pretension Force: 28 kips
Failure Load: 46.3 kips (144.7 ft. - kips)
Failure Mode: Yielding of end-plate
Predicted Failure Loads:
Method: Yield-line theory Load: 43.65 kips (136.4 ft. - kips)
Method: _____ Load: _____
Maximum Displacements:
Vertical: 1.035 in.
Horizontal top flange: 0.241 in.
Horizontal bottom flange: 0.166 in.
Maximum plate separation: East: 0.0 Centerline: 0.0826 in. West: 0.049 in.

Discussion:

- Maximum applied moment was 144.7 ft. - kips at the end-plate.
- Vertical displacement was close to theoretical up to a moment of 142.5 ft. - kips.
- Plate separation was not predicted well by the theoretical line.
- Bolt forces exceeded the proof load at a moment of 136 ft. - kips.



a) Elevation



b) End Plate

Figure F.1 Test Specimen Geometry, Test F2-3/4-3/8-24

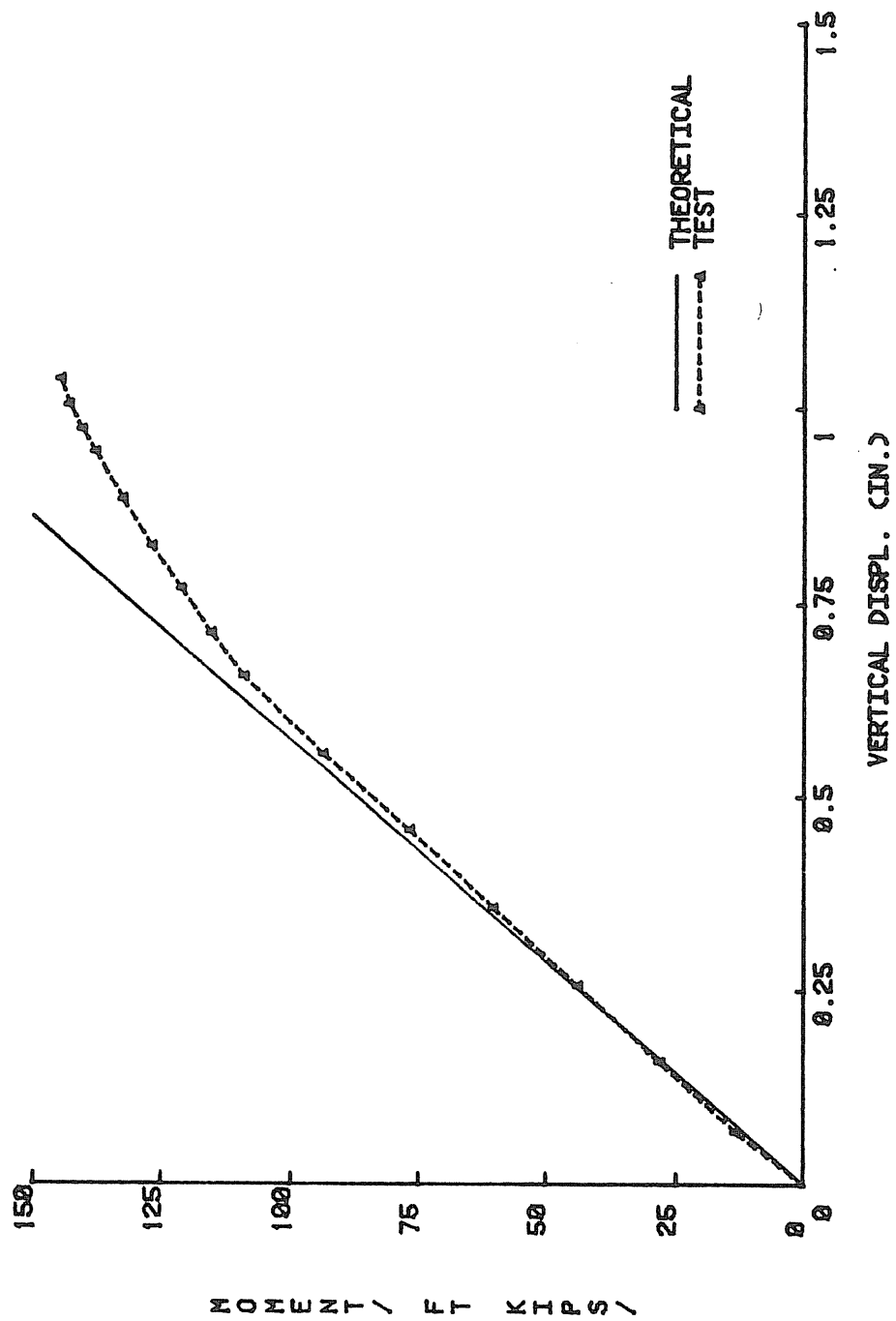


Figure F.2 Moment vs. Vertical Displacement, Test F2-3/4-3/8-24

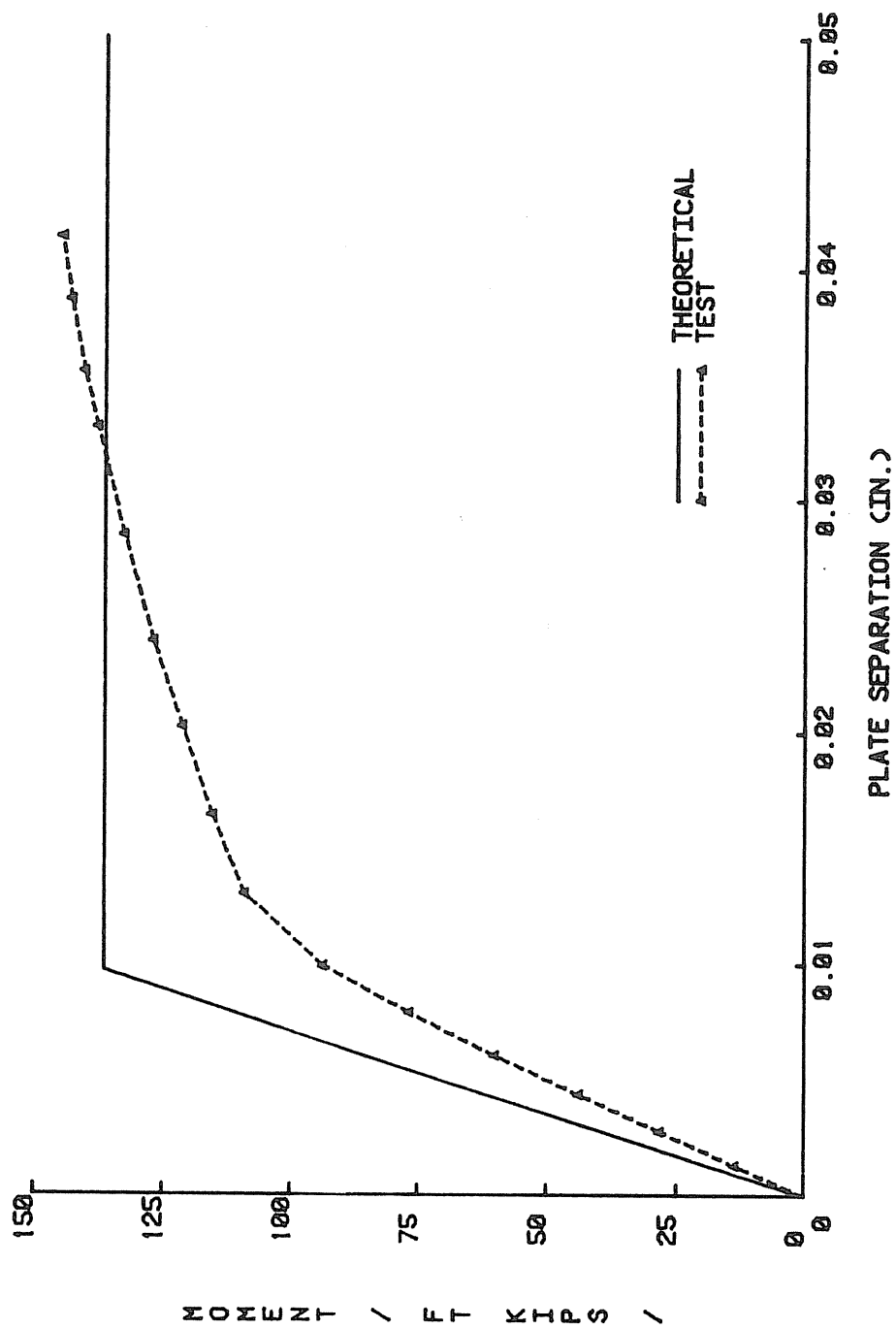


Figure F.3 Moment vs. Plate Separation, Test F2-3/4-3/8-24

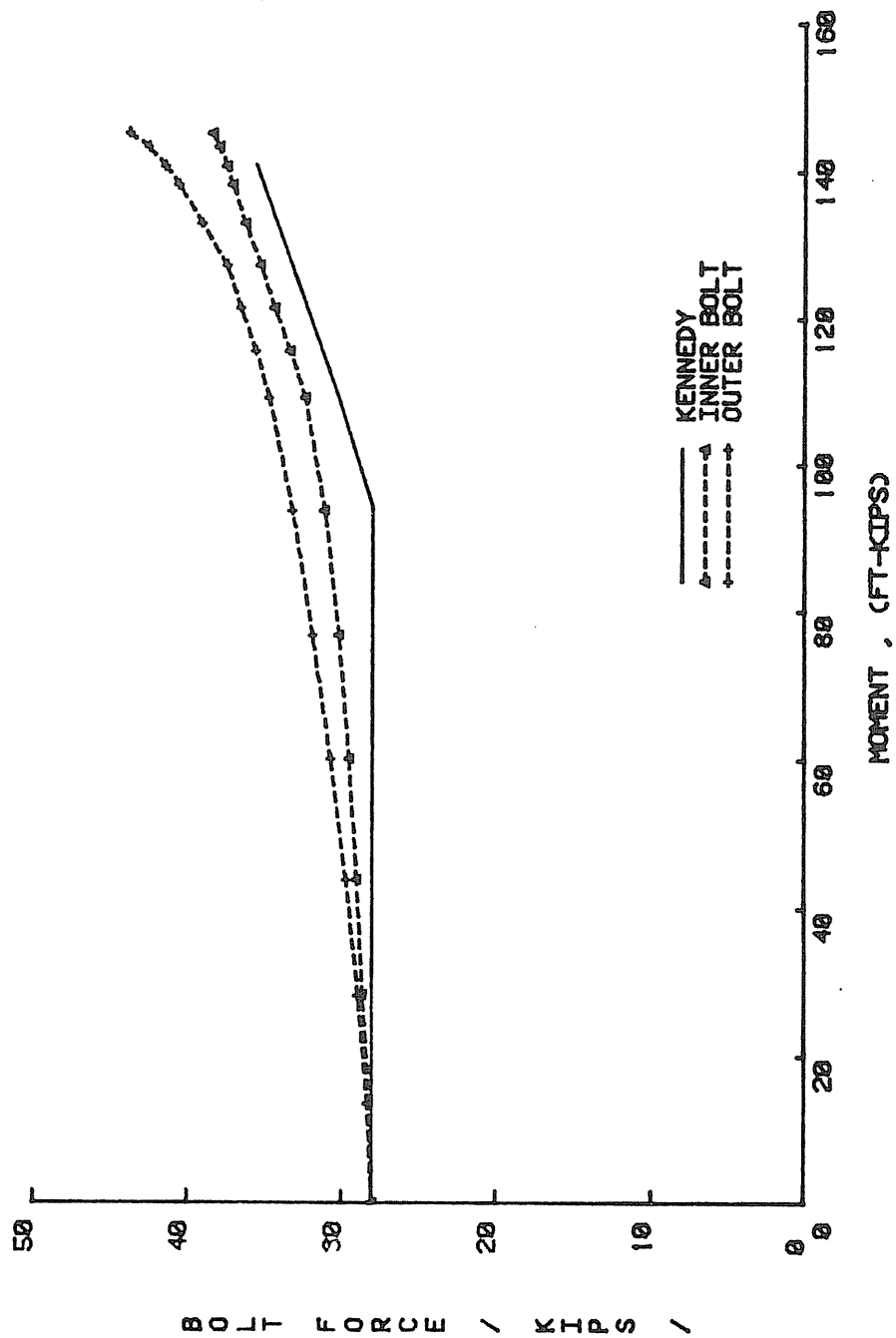


Figure F.4 Bolt Force vs. Moment, Test F2-3/4-3/8-24

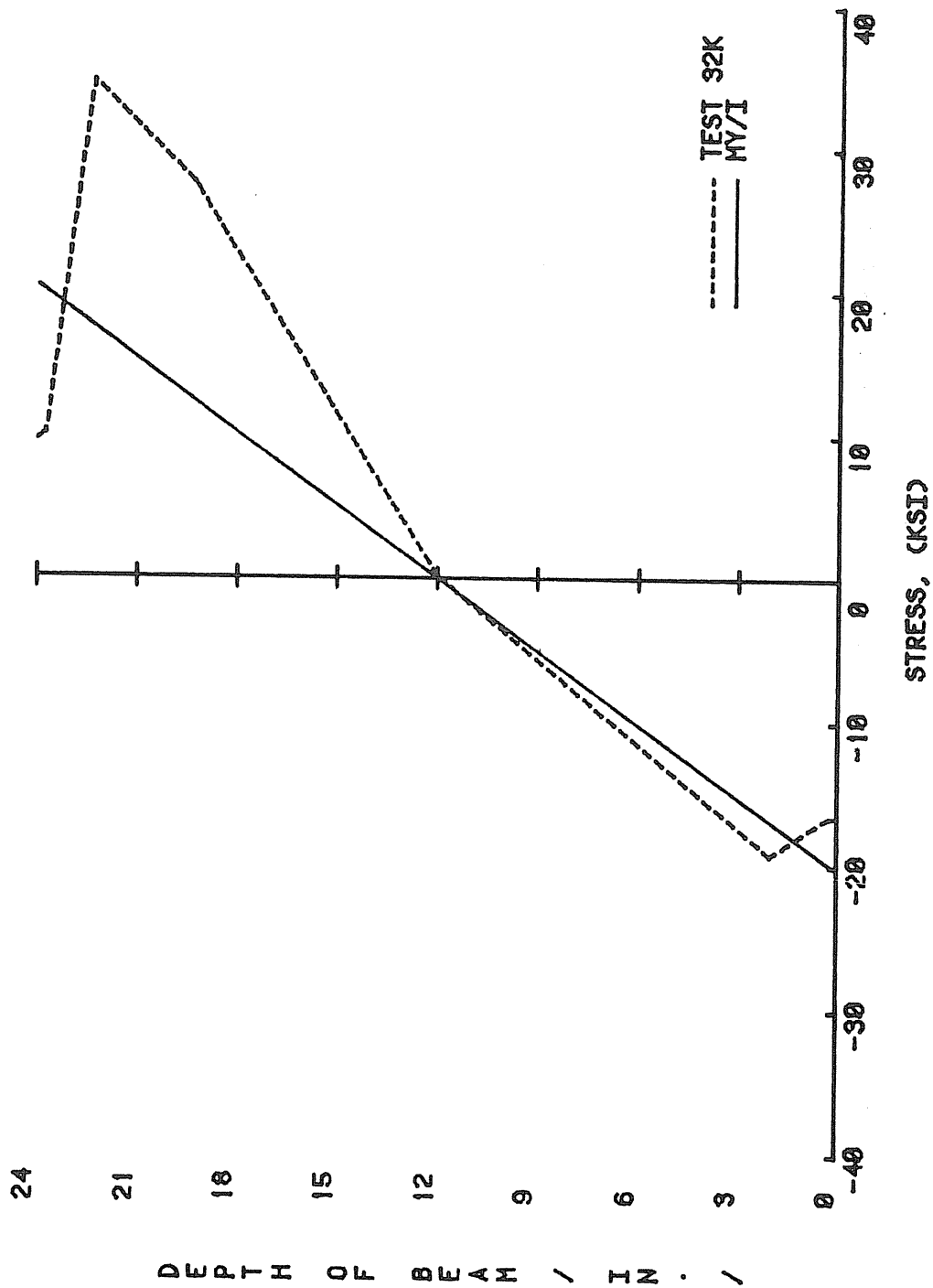


Figure F.5 Stress Distribution 2 in. from End-Plate at 32 kips,
Test F2-3/4-3/8-24

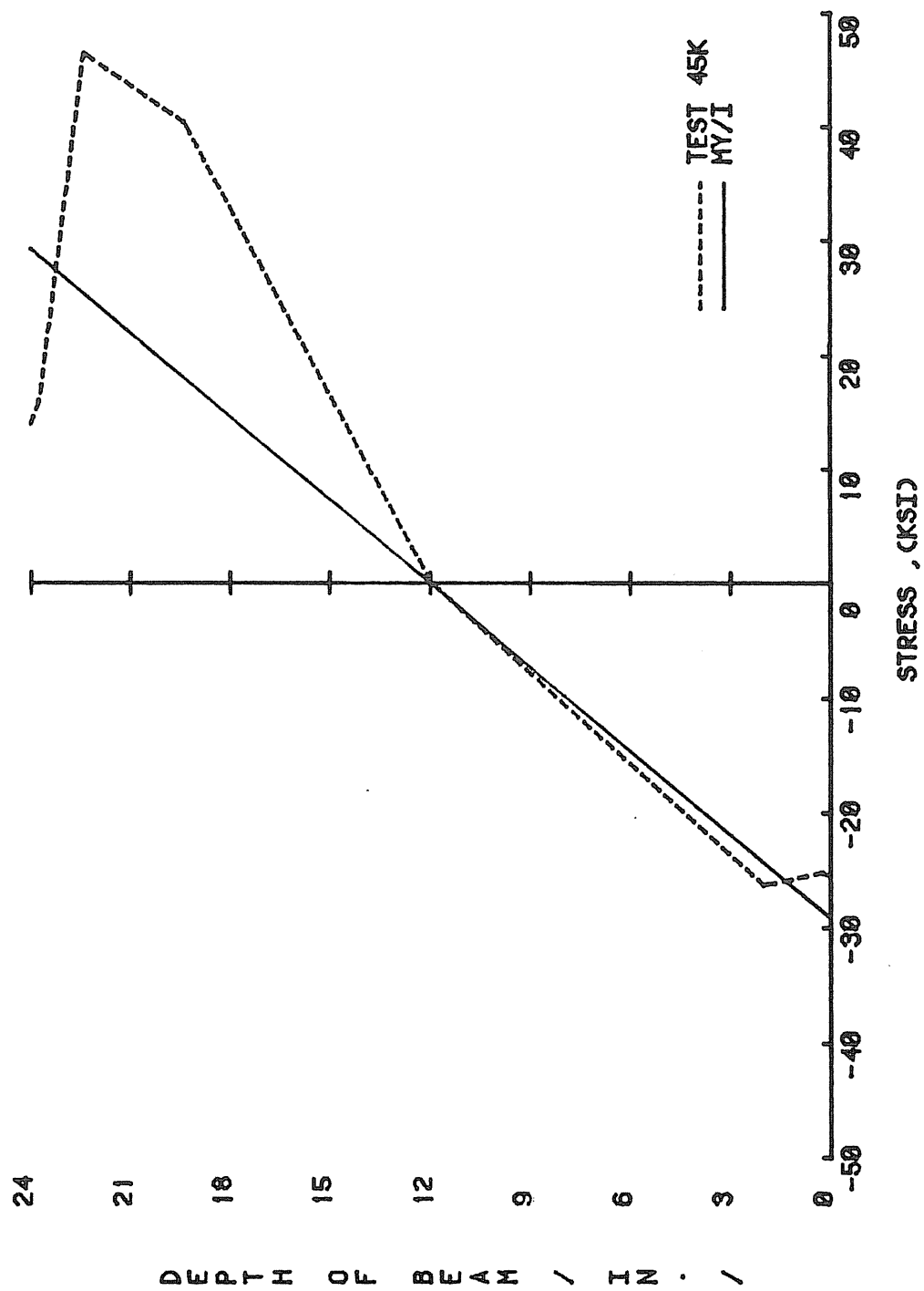


Figure F.6 Stress Distribution 2 in. from End-Plate at 45 kips,
Test F2-3/4-3/8-24

APPENDIX G

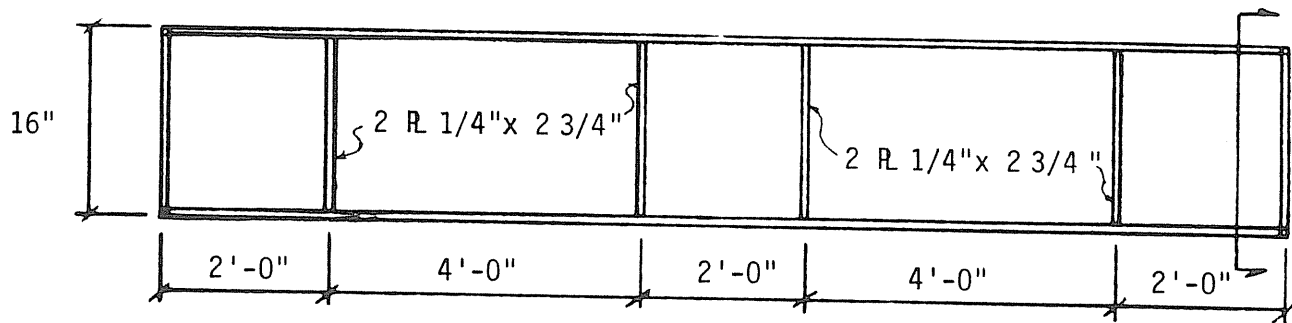
F2-3/4-3/8-16 TEST RESULTS

MBMA TEST SUMMARY

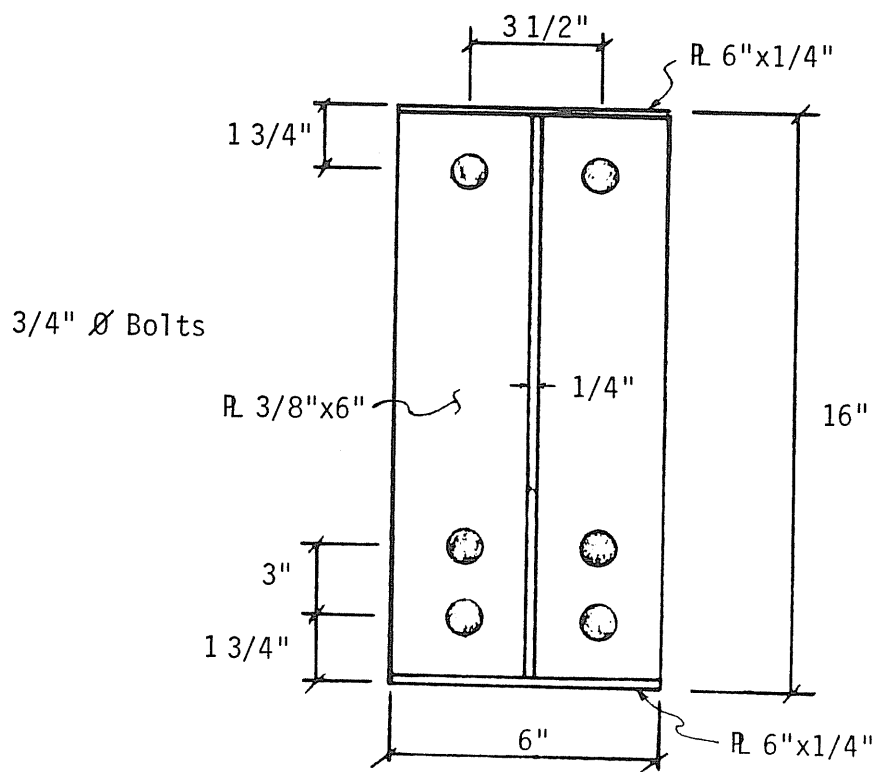
Project: MBMA Splice Connections
Test No.: F2-3/4-3/8-16
Test Date: 11/16/84
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 3/4 in. Plate Thickness: 3/8 in.
Beam Depth: 16 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 263.6 in.⁴
Pretension Force: 28 kips
Failure Load: 23.7 kips (73.2 ft. - kips)
Failure Mode: Yielding of end-plate
Predicted Failure Loads:
Method: Yield-line theory Load: 22.3 kips (68.8 ft. -
Method: Load: kips)
Maximum Displacements:
Vertical: 1.441 in.
Horizontal top flange: 0.164 in.
Horizontal bottom flange: 0.008 in.
Maximum plate separation: East: 0.0 Centerline: 0.0556 in. West: 0.0346 in.

Discussion:

- Maximum applied moment was 73.2 ft. - kips at the end-plate.
- Failure was due to failure at end-plate.
- Vertical displacement was close to theoretical all the way to failure.
- Plate separation close to theoretical up to a moment at 65 ft. - kips.
- Bolt forces reached proof load just before failure.



a) Elevation



b) End Plate

Figure G.1 Test Specimen Geometry, Test F2-3/4-3/8-16

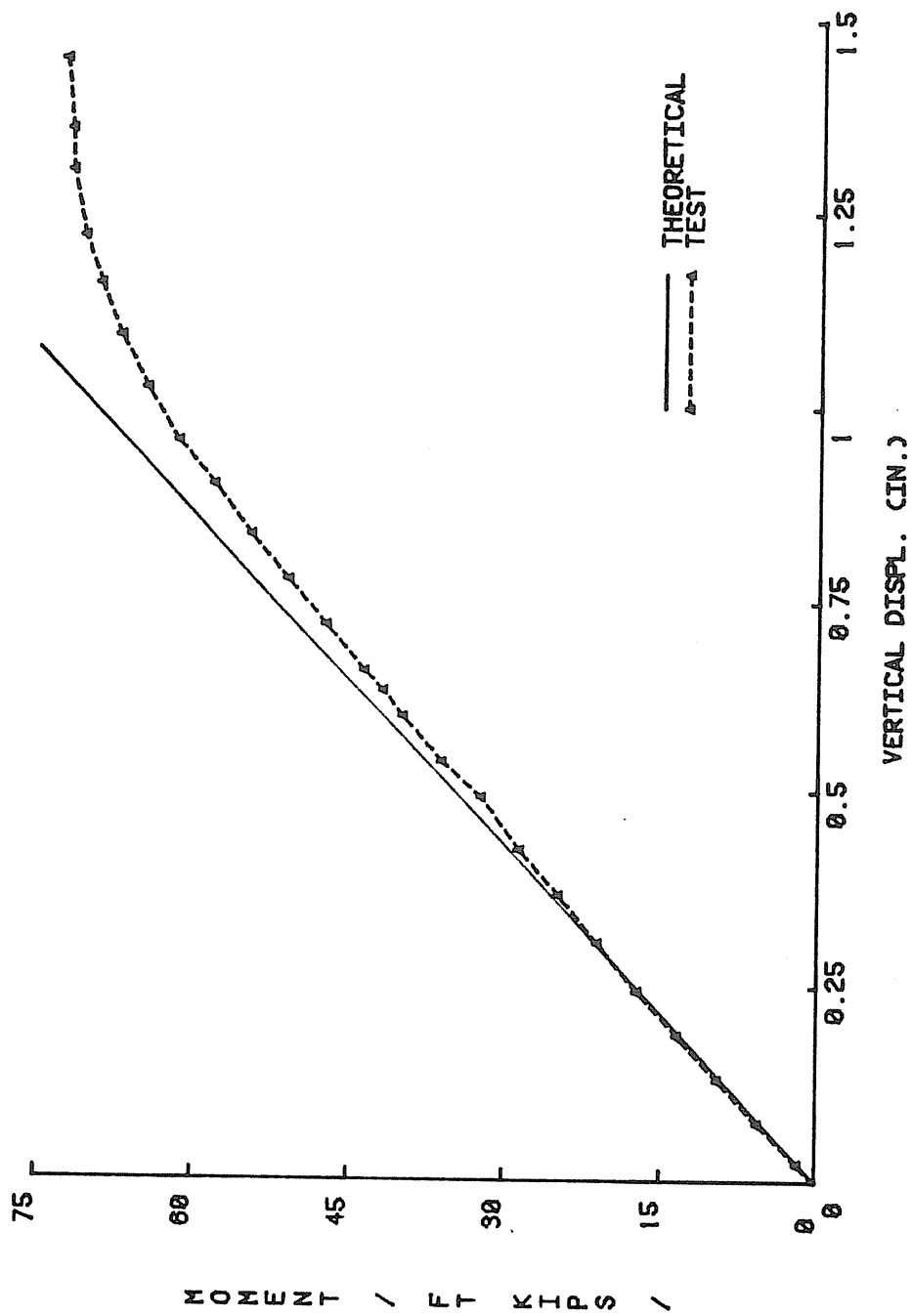


Figure G.2 Moment vs. Vertical Displacement, Test F2-3/4-3/8-16

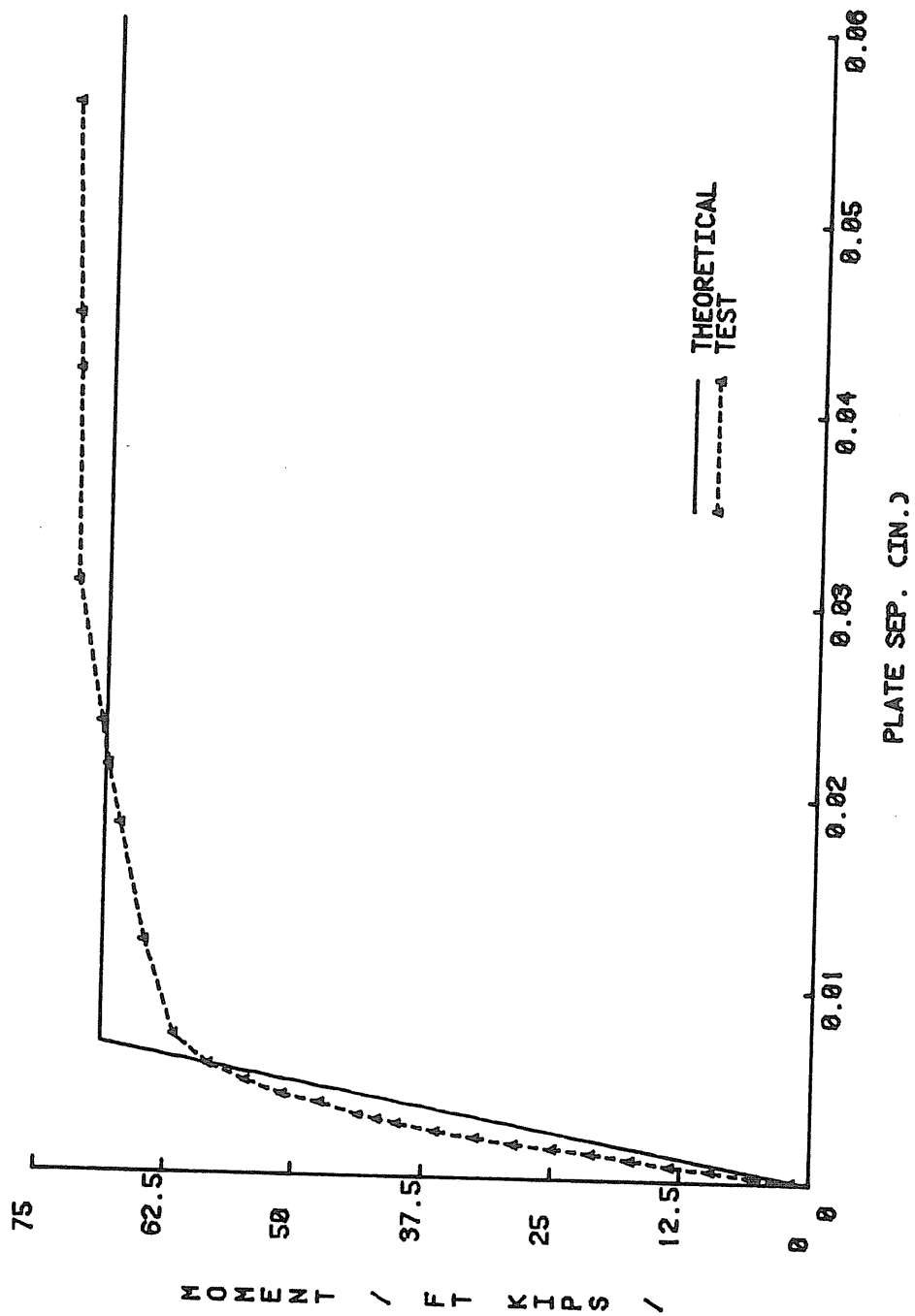


Figure G.3 Moment vs. Plate Separation, Test F2-3/4-3/8-16

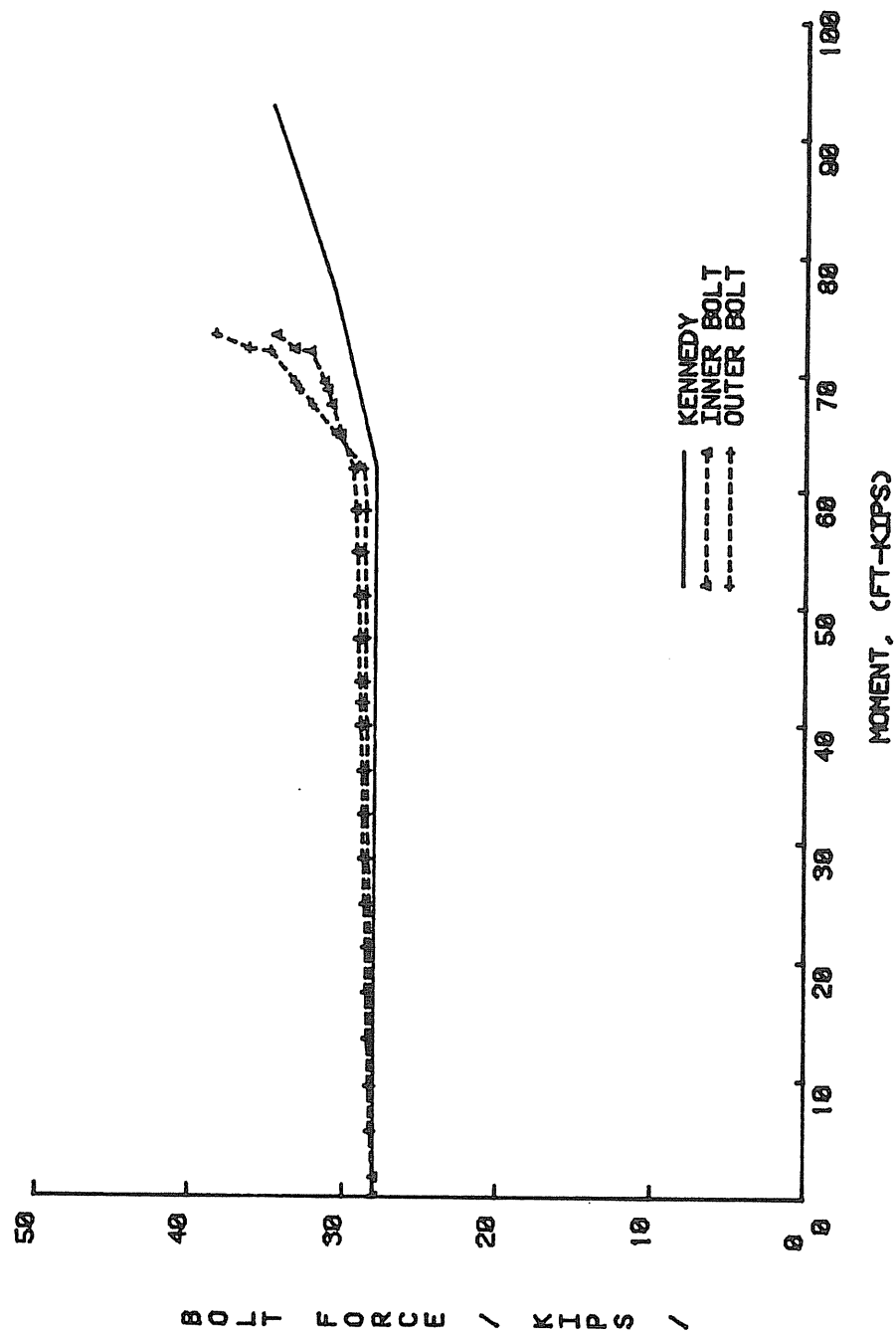


Figure G.4 Bolt Force vs. Moment, Test F2-3/4-3/8-16

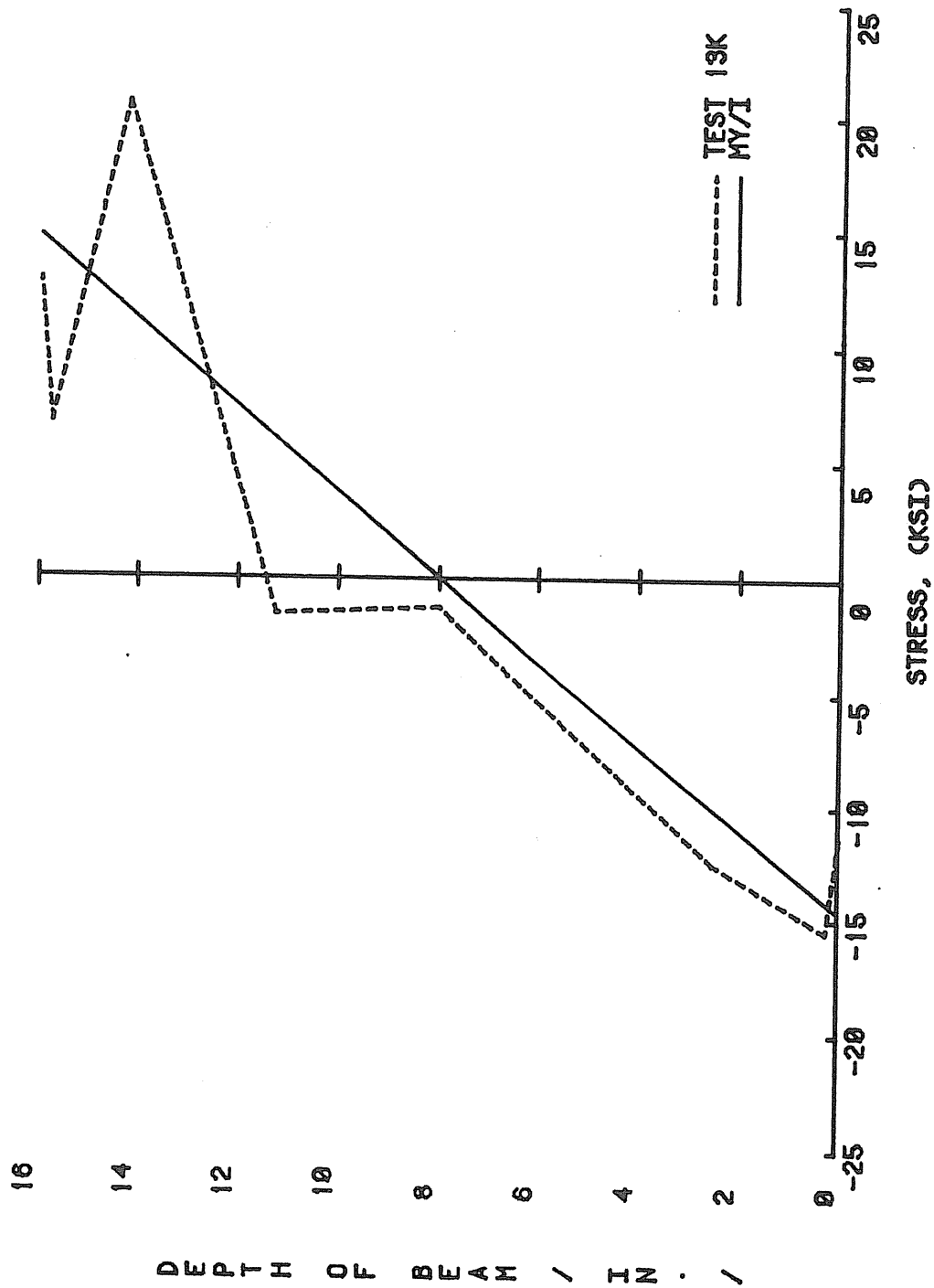


Figure G.5 Stress Distribution 2 in. from End-Plate at 13 kips,
Test F2-3/4-3/8-16

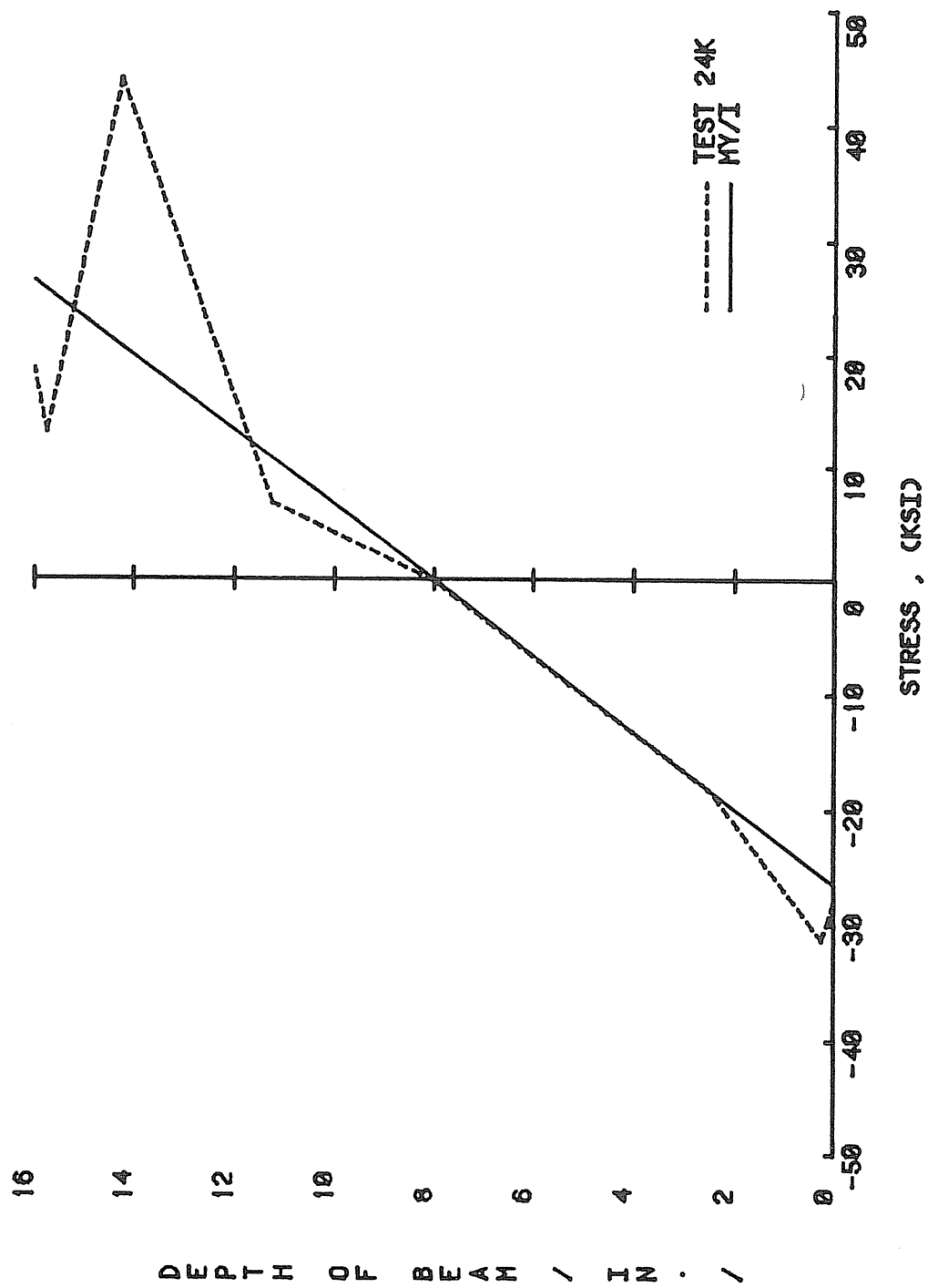


Figure G.6 Stress Distribution 2 in. from End-Plate at 24 kips,
Test F2-3/4-3/8-16

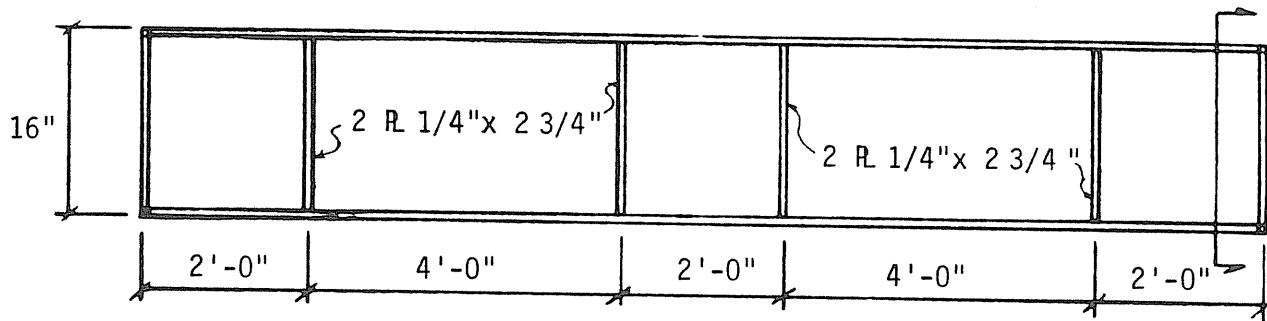
APPENDIX H
F2-3/4-1/2-16 TEST RESULTS

MBMA TEST SUMMARY

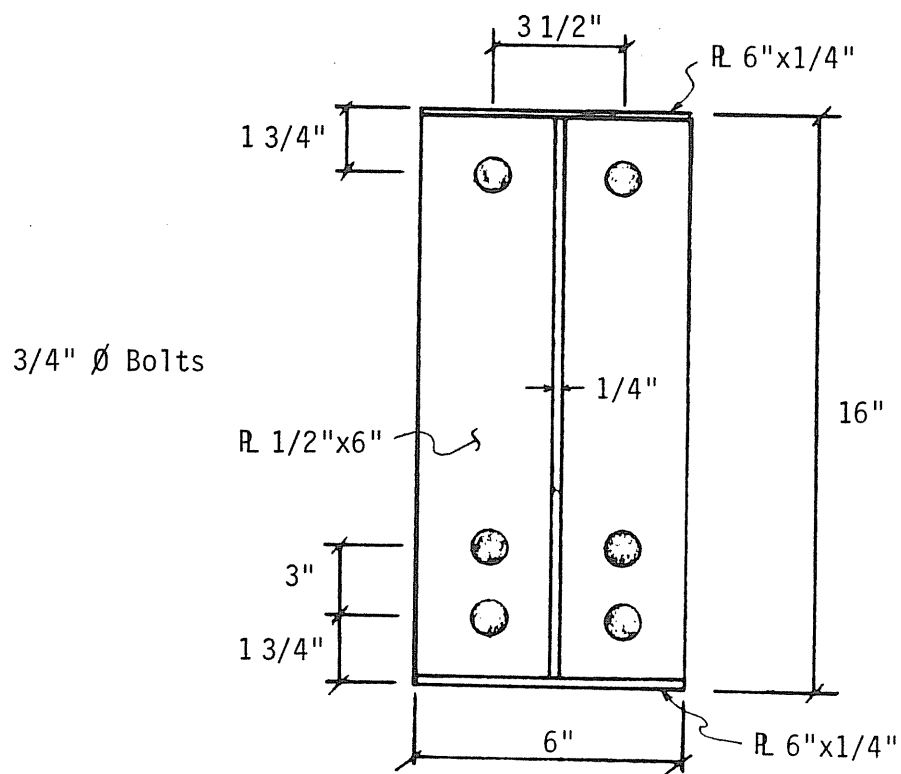
Project: MBMA Splice Connections
Test No.: F2-3/4-1/2-16
Test Date: 11/18/83
Purpose: Load to failure
Rows of Bolts in Tension: 2 Bolts/Row: 2
Bolt Diameter: 3/4 in. Plate Thickness: 1/2 in.
Beam Depth: 16 in. Flange Width: 6 in.
Web Thickness: 1/4 in. Flange Thickness: 1/4 in.
Moment of Inertia: 263.6 in.⁴
Pretension Force: 28 kips
Failure Load: 37.5 kips (115.5 ft. kips)
Failure Mode: Yielding of end-plate
Predicted Failure Loads:
Method: Yield-line theory Load: 36.4 kips (112.2 ft. -
Method: Load: kips)
Maximum Displacements:
Vertical: 3.34 in.
Horizontal top flange: 1.734 in.
Horizontal bottom flange: 0.594 in.
Maximum plate separation: East: 0.0 Centerline: 0.0931 West: 0.08 in.

Discussion:

- Maximum applied moment was 115.5 ft. - kips at the end-plate.
- Vertical displacement was close to theoretical up to a moment at 104 ft. - kips. At this point the curve started to lean over.
- Plate separation was close to theoretical up to a moment at 74 ft. - kips.
- Bolt forces reached the proof load at a load at 92 ft. - kips.



a) Elevation



b) End Plate

Figure H.1 Test Specimen Geometry, Test F2-3/4-1/2-16

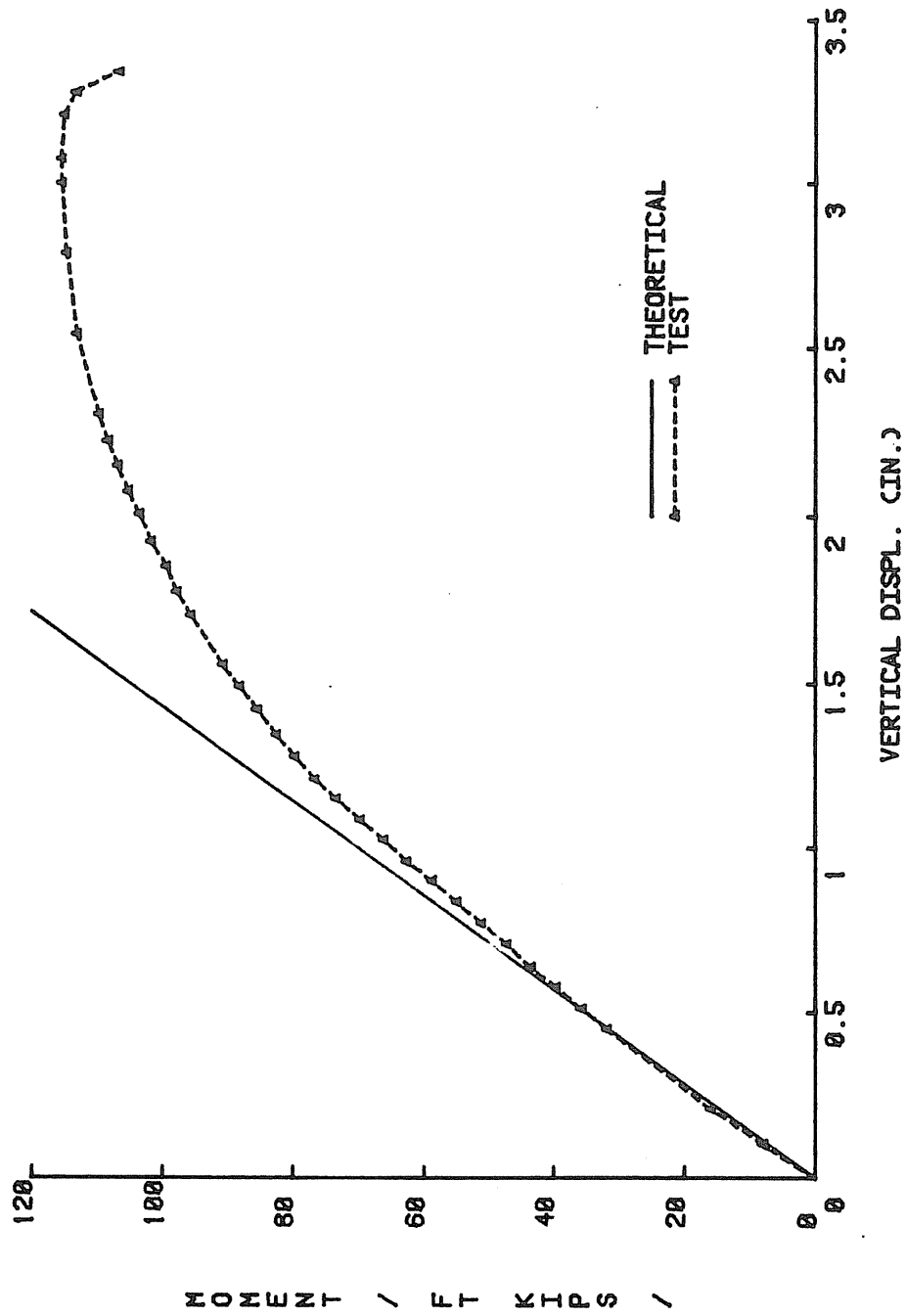


Figure H.2 Moment vs. Vertical Displacement, Test F2-3/4-1/2-16

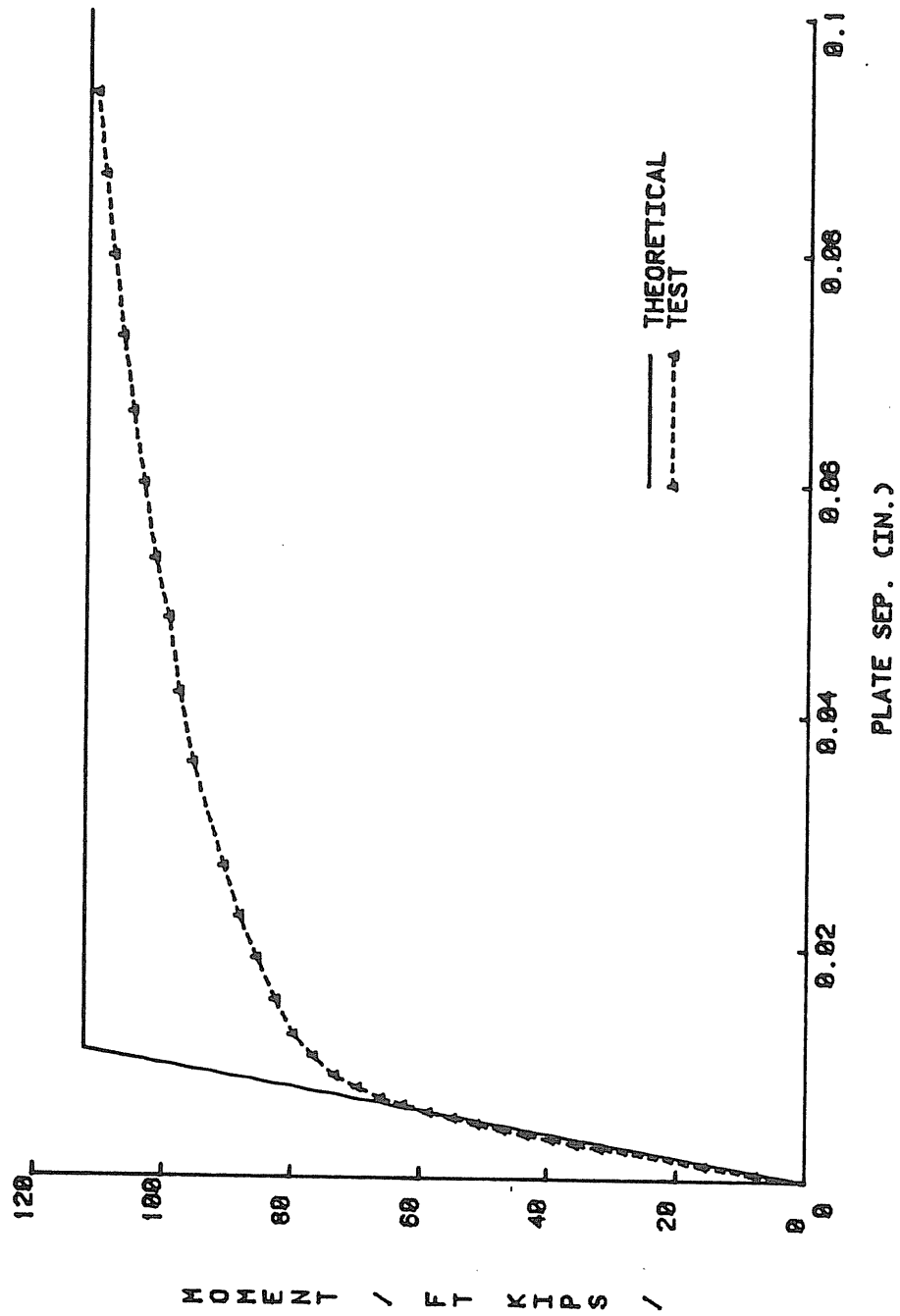


Figure H.3 Moment vs. Plate Separation, Test F2-3/4-1/2-16

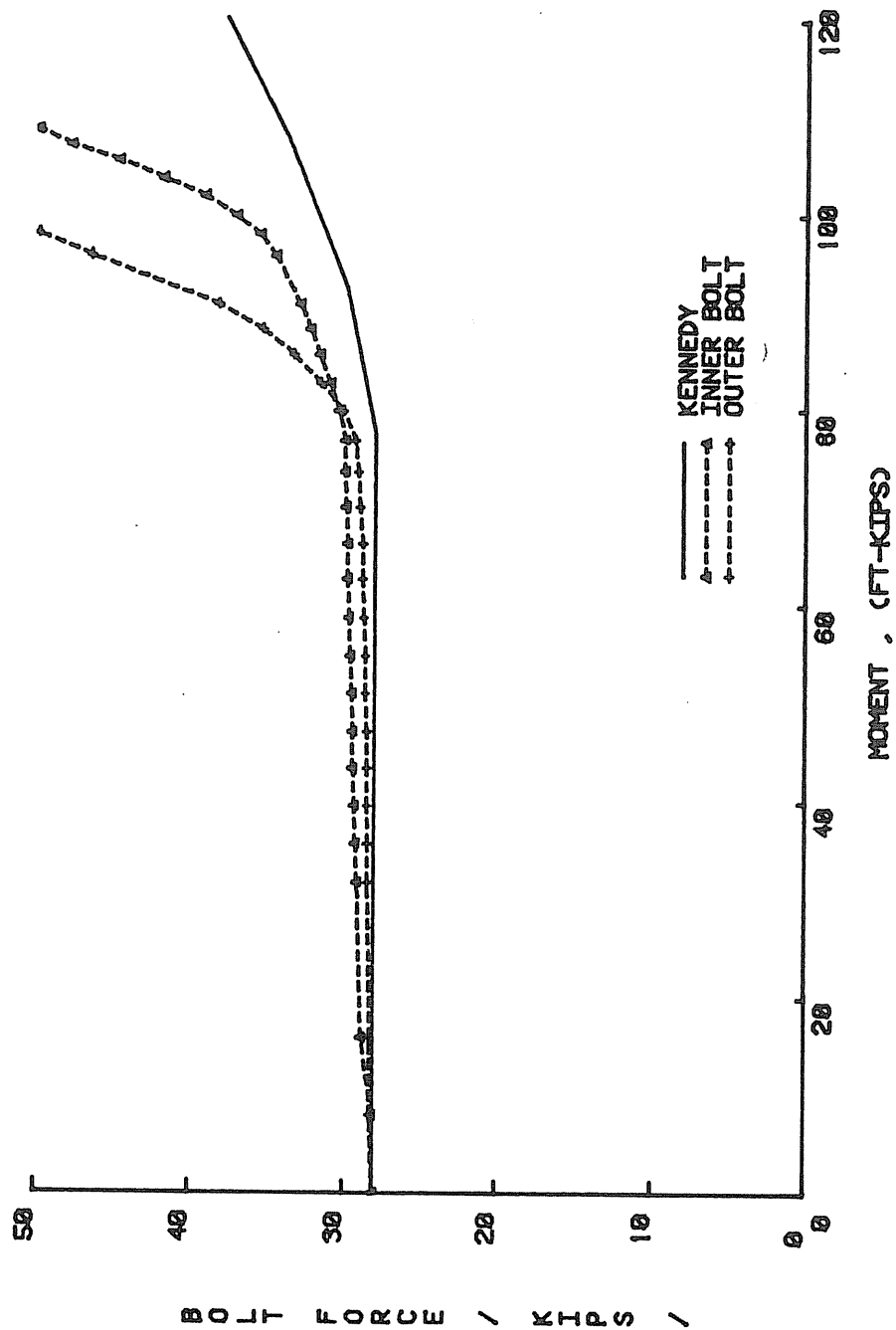


Figure H.4 Bolt Force vs. Moment, Test F2-3/4-1/2-16

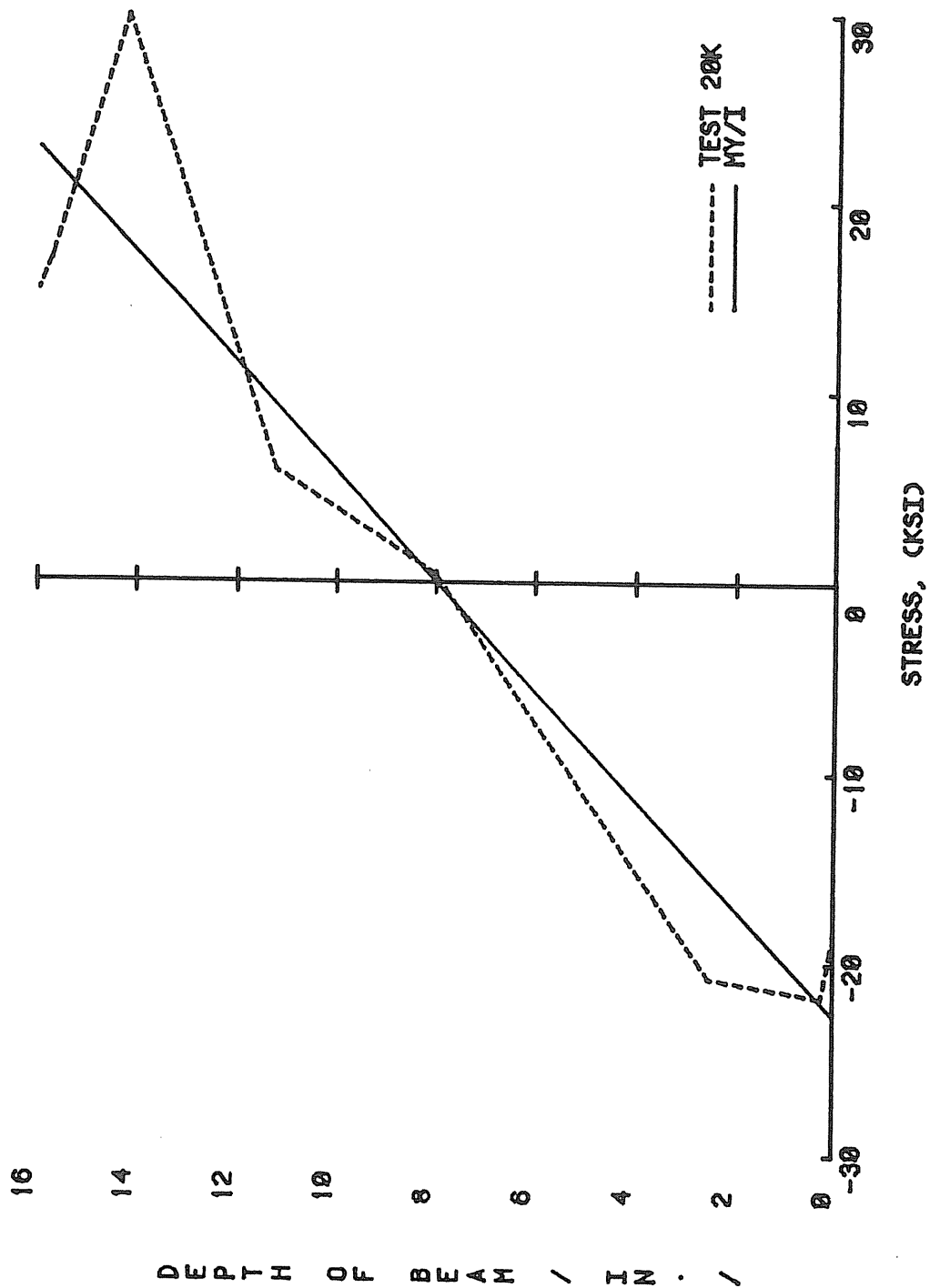


Figure H.5 Stress Distribution 2 in. from End-Plate at 20 kips,
Test F2-3/4-1/2-16

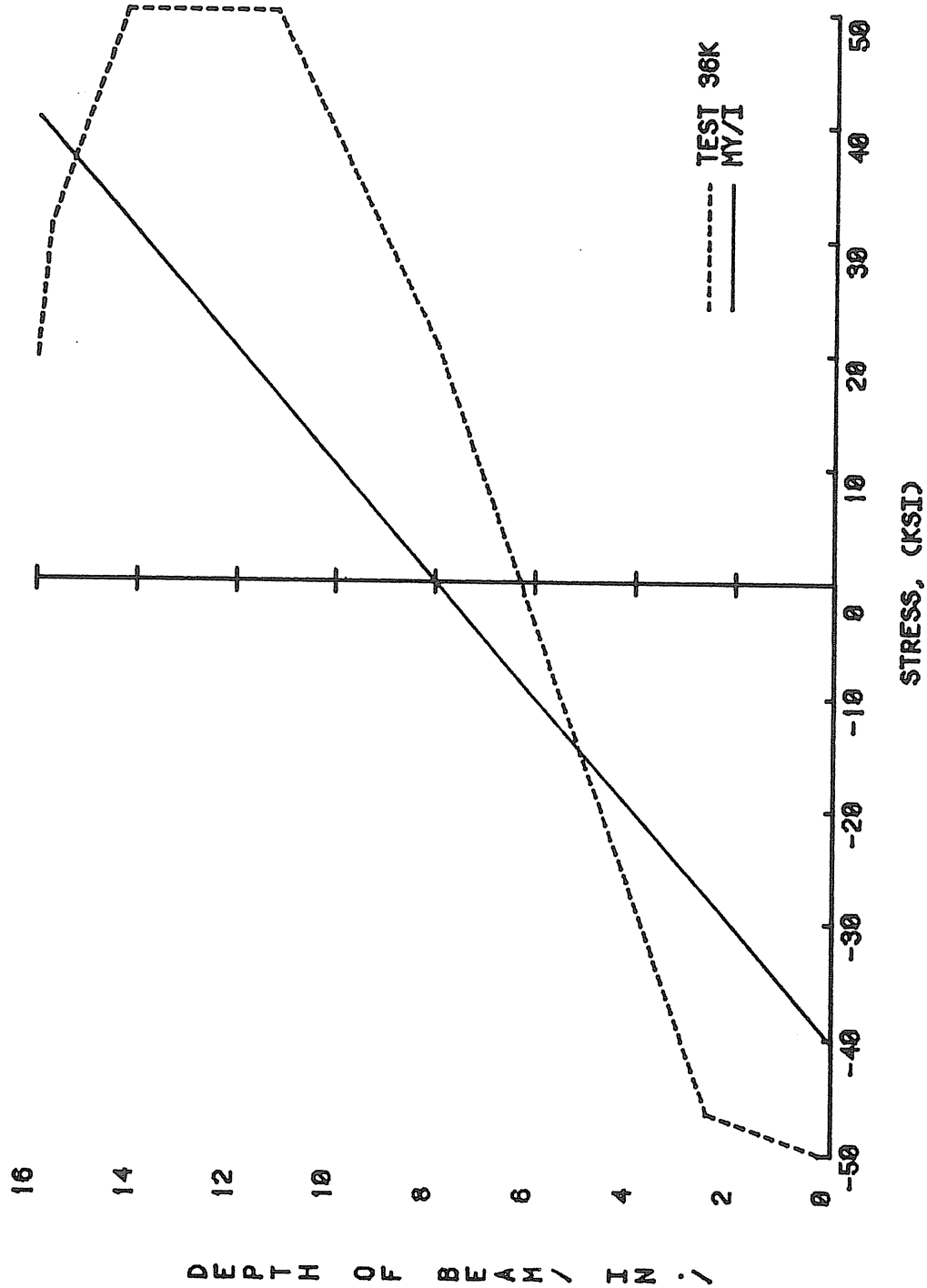


Figure H.6 Stress Distribution 2 in from End-Plate at 36 kips,
Test F2-3/4-1/2-16