FINAL REPORT

TESTING OF THE PEDESTRIAN SAFETY HANDRAIL

INDEX No. 520

By

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TESTING OF THE PEDESTRIAN SAFETY HANDRAIL (INDEX No. 520)

1.0 GENERAL

The Specification Office and the Roadway Design Office recommended an experimental study of the pedestrian safety handrails shown on the Roadway and Traffic Design Standards (Index No. 520). For a pedestrian hand railing system to be considered, it should meet all the AASHTO and the State/Local codes design criteria. The testing will give the engineer more information about the behavior of these railings under the design loads. Since the posts were the most critical members of the handrail system, therefore, they recommended that it test them first in this study.
The results of the experimental program are presented in this report.

2.0 OBJECTIVE

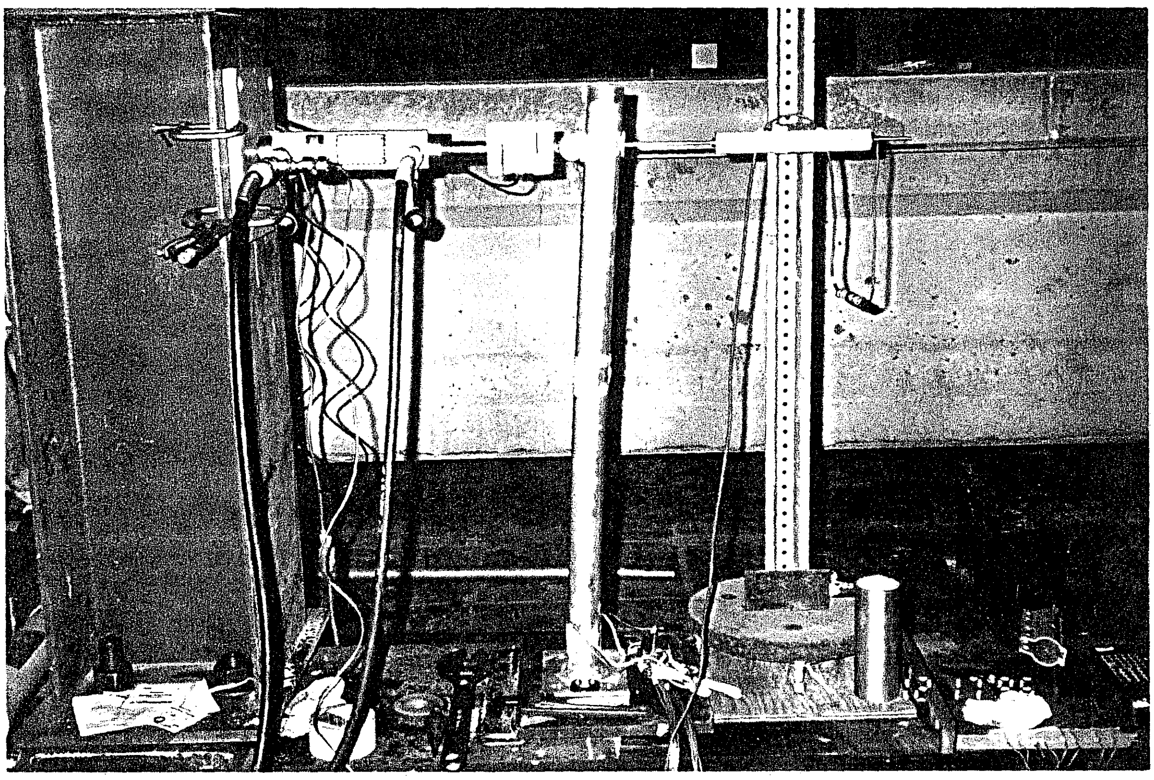
The objective of this testing program is to investigate the behavior of four different hand railing posts. Moment vs. Deflection and strain as well as the ultimate loads and modes of failure will be presented and discussed.

3.0 TEST SETUP AND INSTRUMENTATION

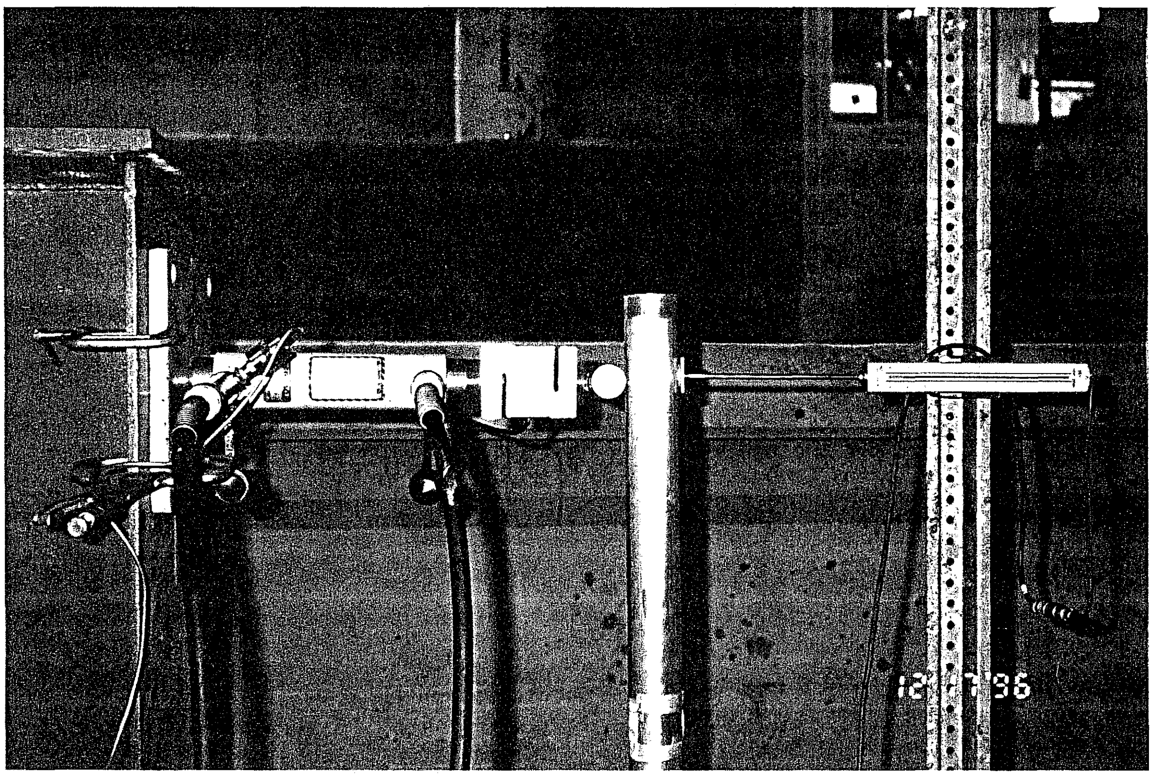
The post was bolted down at the base plate (6"x8"x1/2" base plate) with 2-1/2" diameter bolts. Rosette strain gages were installed at 1" from the base plate on the tension and compression sides of the post. A load cell to measure the load and an LVDT (Linear Voltage Differential Transducer) to measure the deflection under the loading point were used in this test. All gages were connected to an Optim Electronic high speed Data Acquisition system to collect and store the data for later analysis. See Figures 1 through 3 for a typical test setup and instrumentation.

4.0 PROCEDURE

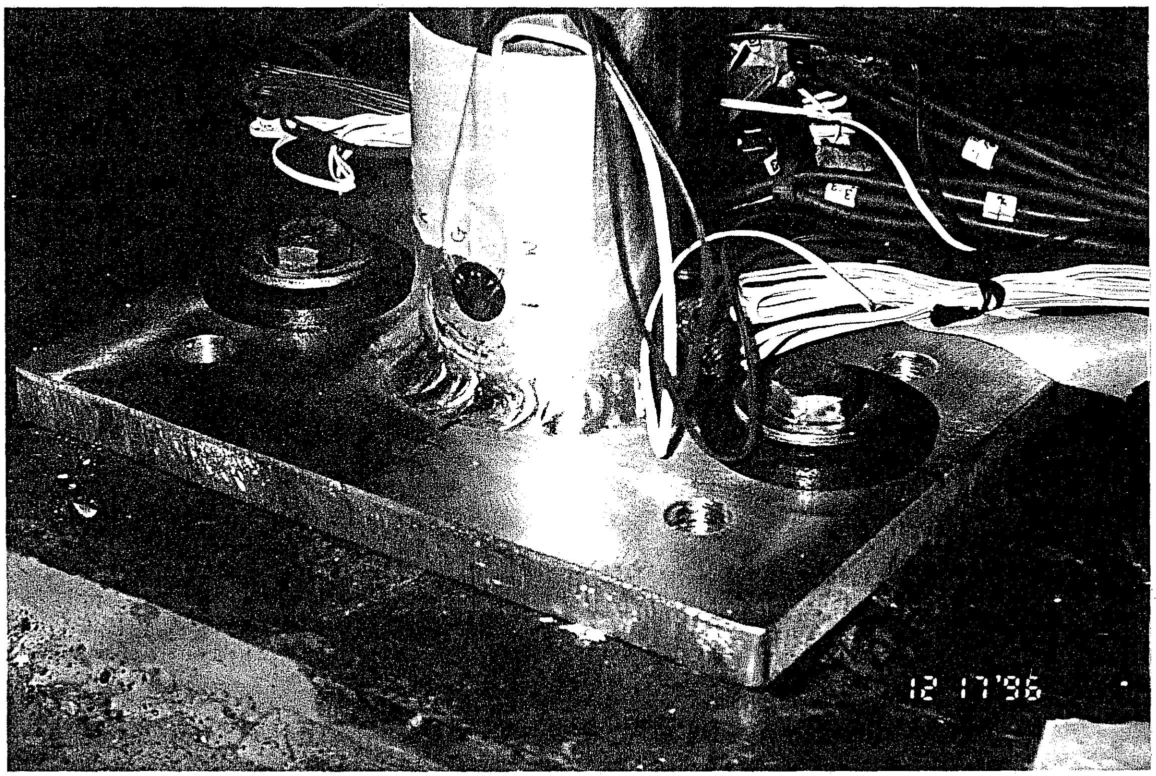
The posts were loaded in small load increments up to 300 lbs. in the horizontal direction at 37.5" from the base. Then unload the post and check for any permanent set. Reload the post with the same procedures as before till failure occurred. All strain, deflection and load data were recorded and stored by the Data Acquisition system.



GENERAL TEST SETUP
FIGURE 1



LOAD CELL AND LVDT INSTRUMENTS
FIGURE 2



BASE PLATE AND ROSETTE STRAIN GAGES
FIGURE 3

5.0 Material Properties

Aluminum 6061-T6

Specific Weight, γ = 170 lb/ft^3, (26 kN/m^3)

Mass Density, ρ = 5.4 slug/ft^3, (2700 kg/m^3)

Modulus of Elasticity, E = 10,000 ksi, (70 Gpa)

Shear Modulus of Elasticity, G = 3,800 ksi, (26 Gpa)

Poisson's ratio, ν = 0.33

Yield Stress, σ_y = 40 ksi, (270 MPa) 35

Ultimate Stress, σ_u = 45ksi, (310 MPa) 42

6.0 Post Load

The Pedestrian hand railing posts shall be designed for a transverse load of wL (where L is the post spacing) acting at the center of gravity of the upper rails. The maximum applied load is based on a design load w = 50 lb/ft, and an allowable post spacing of 6.5 ft.

w = 50 lb/ft

Post height = 37.5 in.

Post spacing = 6.5 ft.

Loading on top of Post = 50 x 6.5 = 325 lbs.

Moment at the base of the post = 325 x 37.5 = 12,187.5 in.-lb (1,015.6 ft-lb)

7.0 Results of Test Specimens

The results for deflections, strains and the modes of failure will be presented and discussed for each post.

7.1 Test Specimen #1

Name	: Specimen "A"
Material	: Aluminum 6061-T6
Outside Diameter	: 2.50"
Thickness	: 0.25"
Post heights	: 37.5"
Moment of Inertia	: 1.1183 in^4.
Section Modulus	: 0.895 in^3.

Design/Service Loads:

Moment at the base of the post = 12,187.5 in.-lb (1,015.6 ft-lb)

Maximum Deflection at 325 lbs, $\delta_{exp.}$ = 0.60 in.

Maximum Bending Stress at 325 lbs, $\sigma_{exp.}$ = 12,500 lb/in^2

Yield Stress of post, σ_y = 40,000 lb/in^2.

σ_{max} / σ_y = 31.3 % of the yield strength of the post.

Ultimate/Failure Loads:

Ultimate load = 1037 lbs.

Ultimate Deflection, $\delta_{max.}$ = 2.98 in.

Mode of Failure :

Failure of weld at base plate (See Figure 4 below)

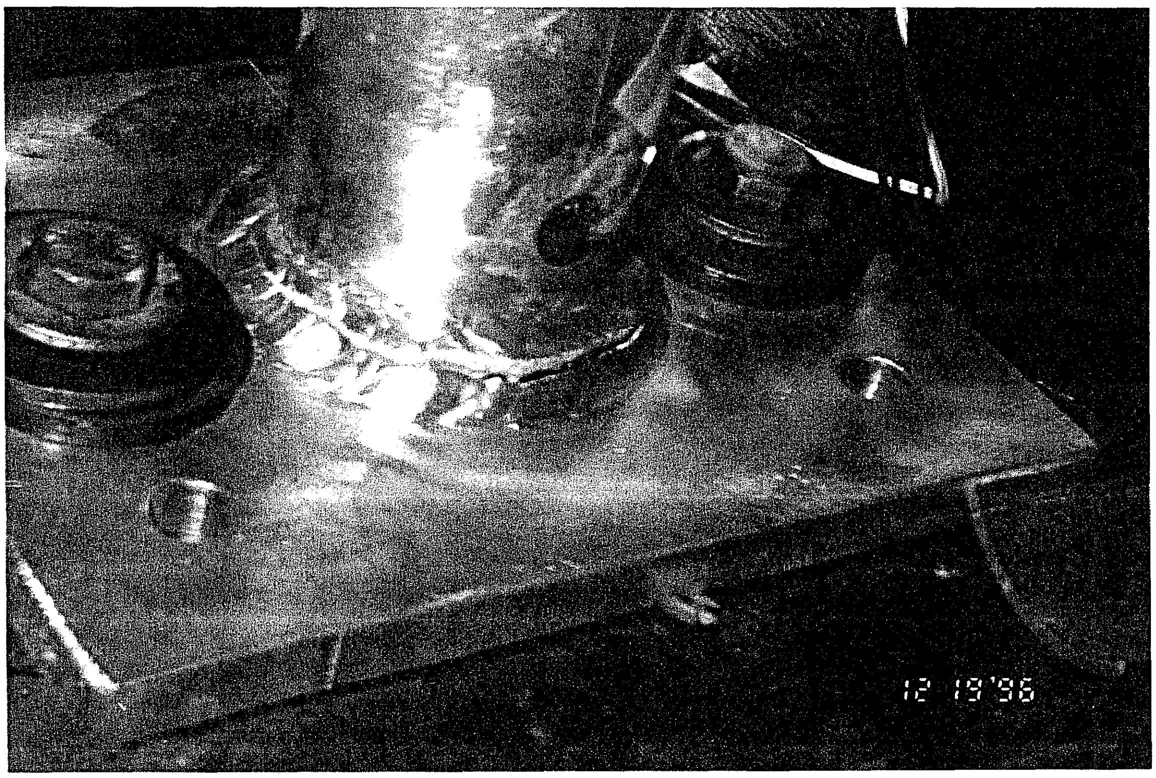


FIGURE 4

Moment vs Load Deflection

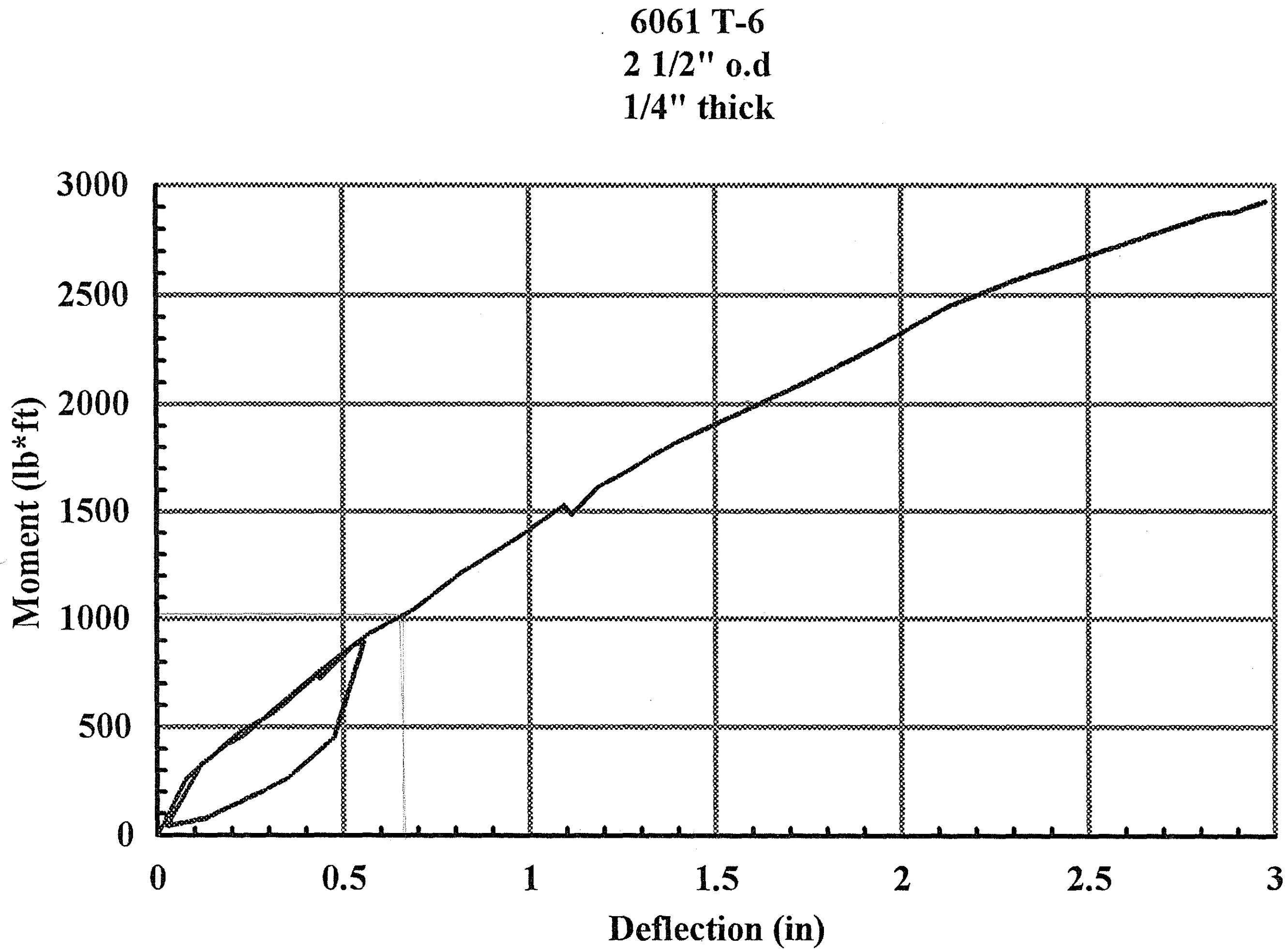


FIGURE 5

Primary strains
Rosette 2

6061 T-6
2 1/2" o.d
1/4" thick

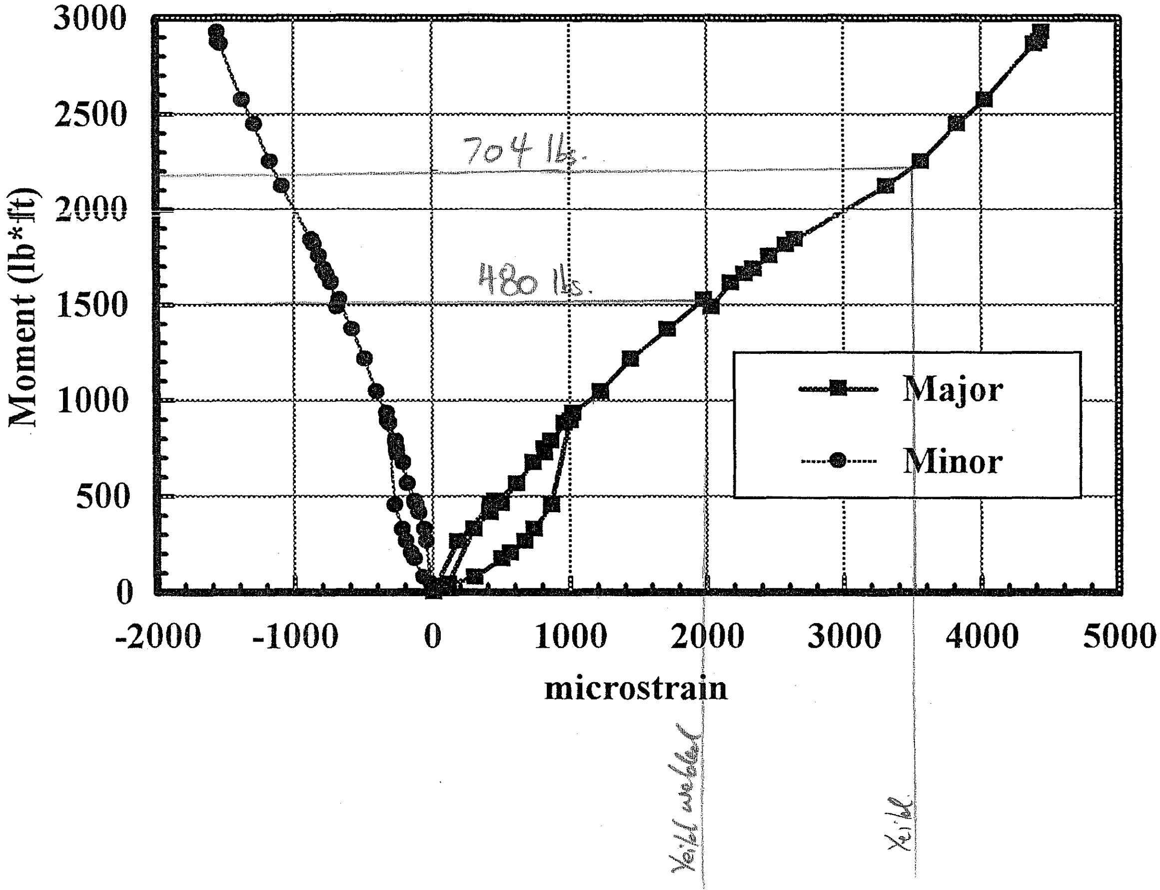


FIGURE 6

7.2 Test Specimen #2

Name	: Specimen "B"
Material	: Aluminum 6061-T6
Outside Diametr	: 2.5"
Thickness	: 0.125"
Post heights	: 37.5"
Moment of Inertia	: 0.658 in^4.
Section Modulus	: 0.562 in^3.

Design/Service Loads:

Moment at the base of the post = 12,187.5 in.-lb (1,015.6 ft-lb)

Maximum Deflection at 325 lbs, $\delta_{exp.}$ = 1.05 in. Theoretical = 1.02"

Maximum Bending Stress at 325 lbs, $\sigma_{exp.}$ = 13,200 lb/in^2 ? 21,686 psi

Yield Stress of post, σ_y = 40,000 lb/in^2.

σ_{exp} / σ_y = 33.0 % of the yield strength of the post.

Ultimate/Failure Loads:

Ultimate load = 570 lbs. σ_a = 38,034 psi.

Ultimate Deflection, $\delta_{max.}$ = 3.21 in.

Mode of Failure :

Failure of weld and post at base plate (See Figure 7 below)

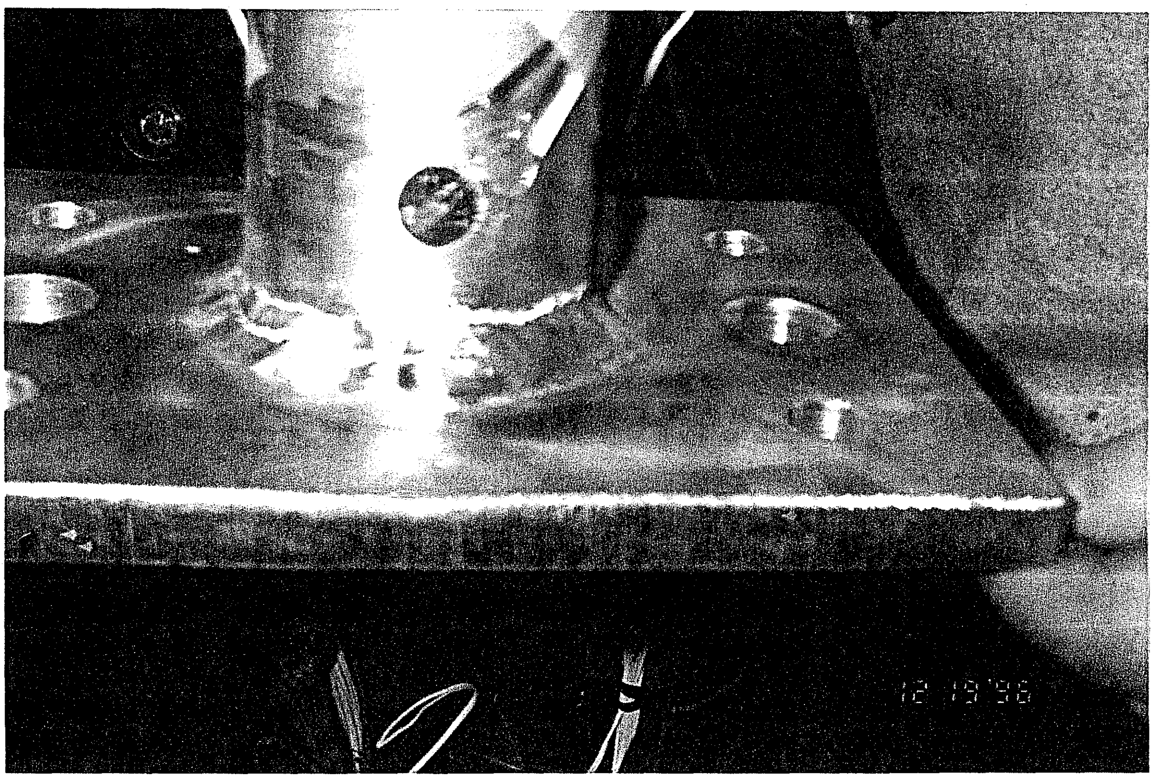


FIGURE 7

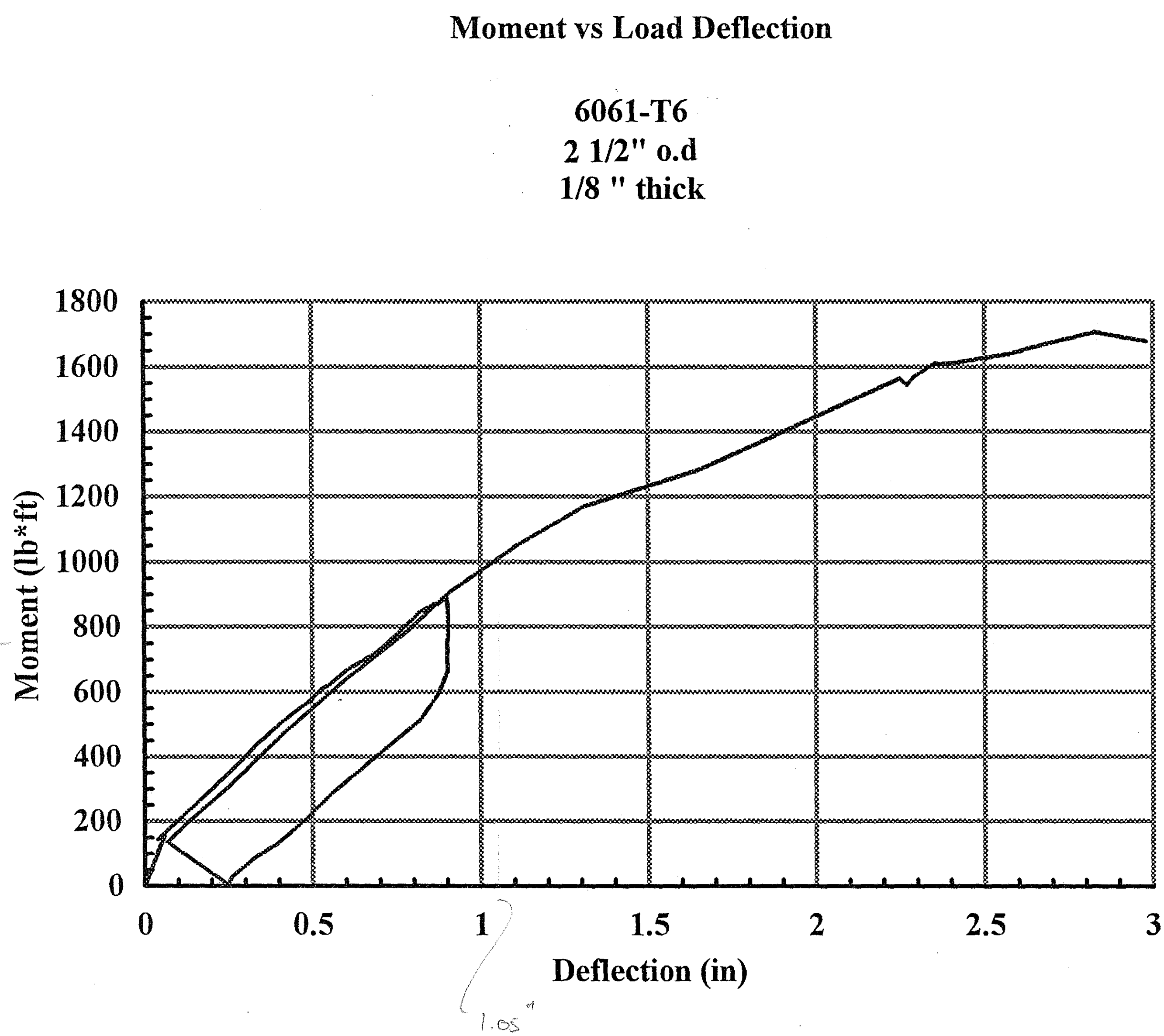

Moment vs Load Deflection
6061-T6
2 1/2" o.d
1/8 " thick
Moment (lb*ft)
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
Deflection (in)
1.05"

FIGURE 8

Primary strains
Rosette 2

6061-T6
2 1/2" o.d
1/8 " thick

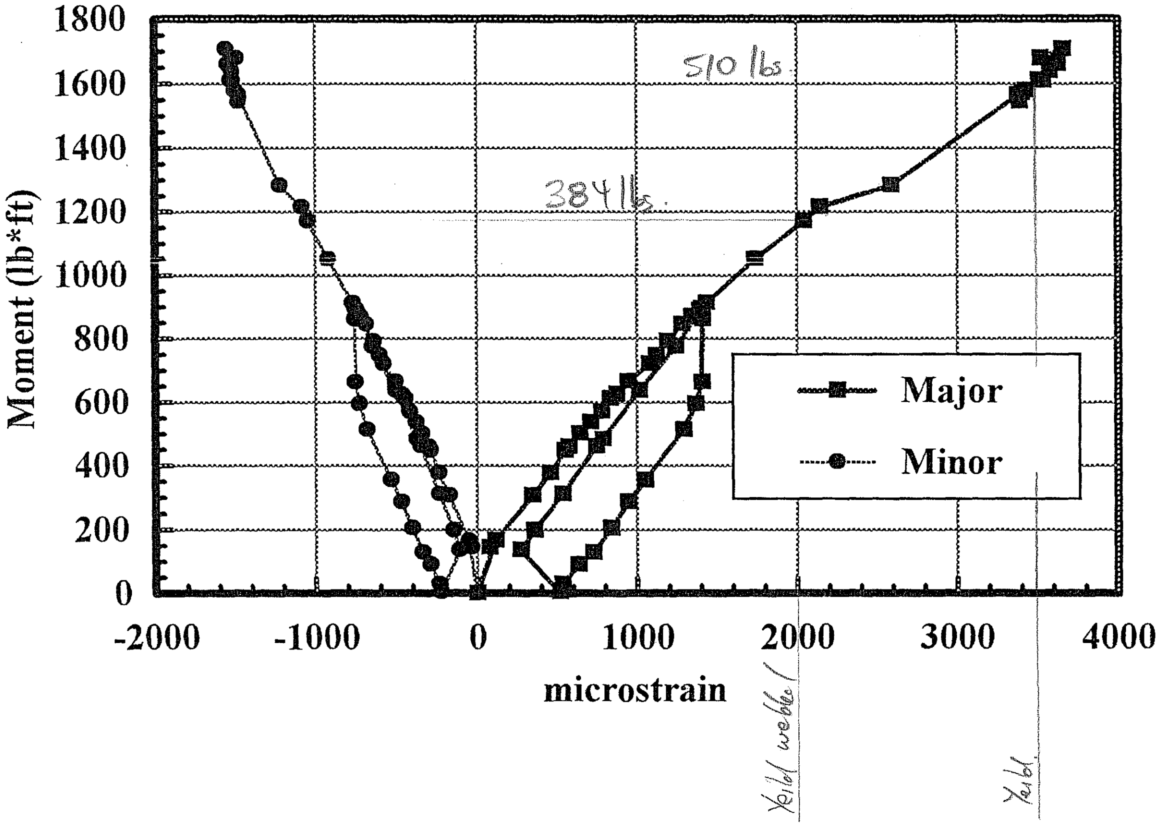


FIGURE 9

7.3 Test Specimen #3

Name	: Specimen "C"
Material	: Aluminum 6061-T6 Sched. 40
Outside Diameter	: 2.375"
Thickness	: 0.154"
Post heights	: 37.5"
Moment of Inertia	: 0.663 in^4.
Section Modulus	: 0.558 in^3.

Design/Service Loads:

Moment at the base of the post = 12,187.5 in.-lb (1,015.6 ft-lb)

Maximum Deflection at 325 lbs, $\delta_{exp.}$ = 1.03 in. Theoretical = 0.86"

Maximum Bending Stress at 325 lbs, $\sigma_{exp.}$ = 17,500 lb/in^2 ? σ_s = 21,841 psi.

Yield Stress of post, σ_y = 40,000 lb/in^2.

σ_{exp} / σ_y = 43.8 % of the yield strength of the post.

Ultimate/Failure Loads:

Ultimate load = 570 lbs. σ ≈ 38,306 psi

Ultimate Deflection, $\delta_{max.}$ = 2.90 in.

Mode of Failure :

Failure of weld and post at base plate (See Figure 10 Below)

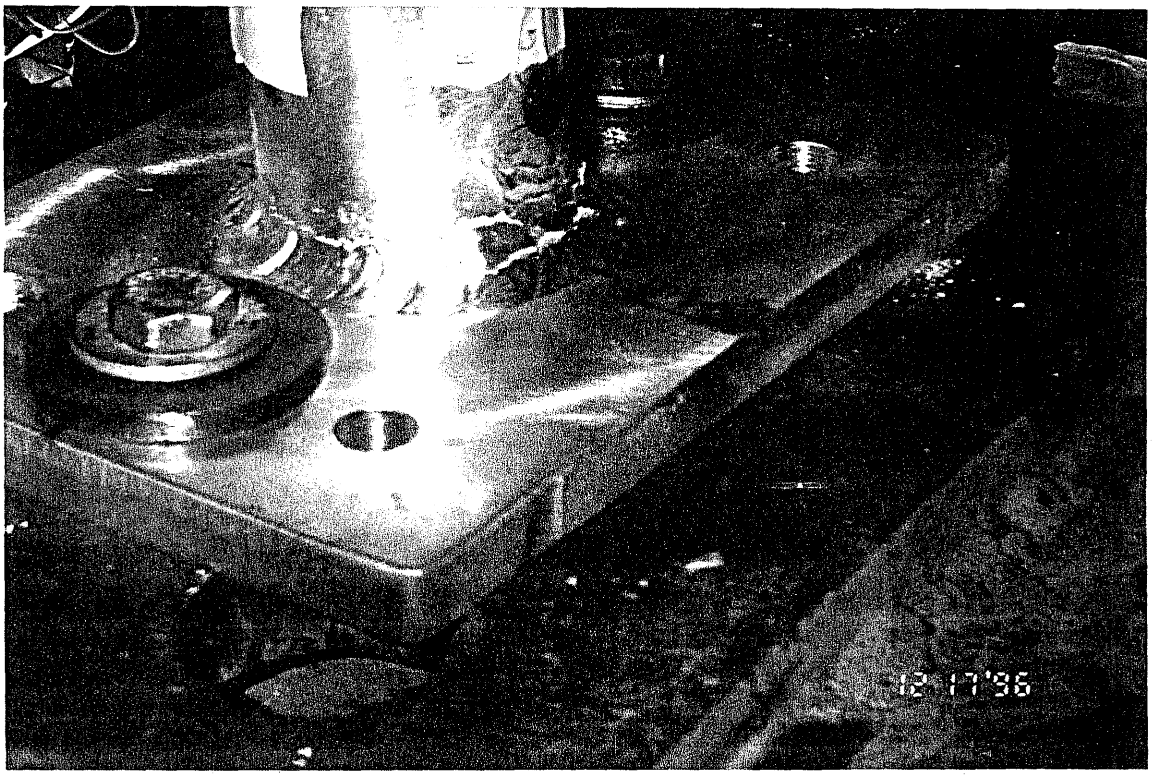


FIGURE 10

Moment vs Load Deflection

6061-T6
schedule 40
2 3/8 o.d.
.154" thick

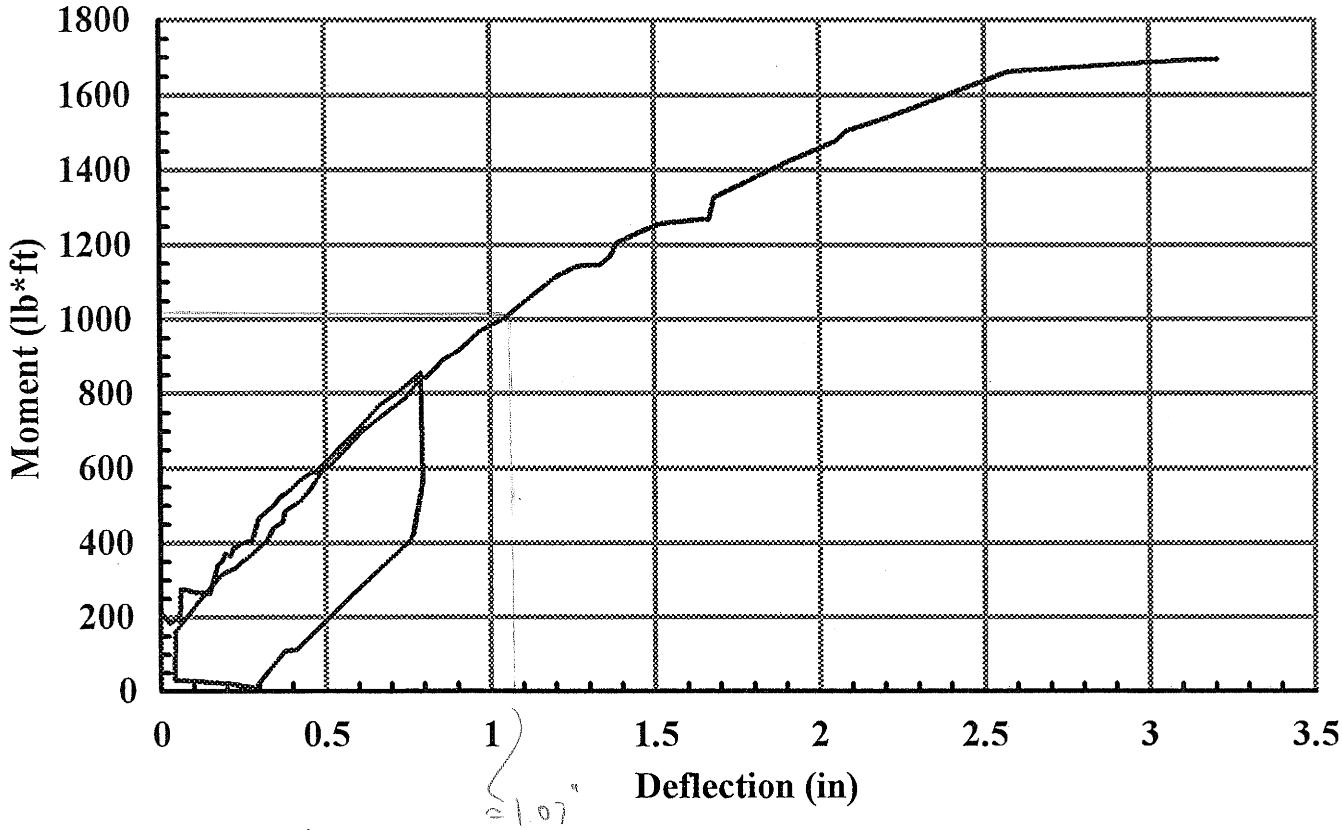


FIGURE 11

Primary strains
Rosette 2

6061-T6
schedule 40
2 3/8 o.d.
.154" thick

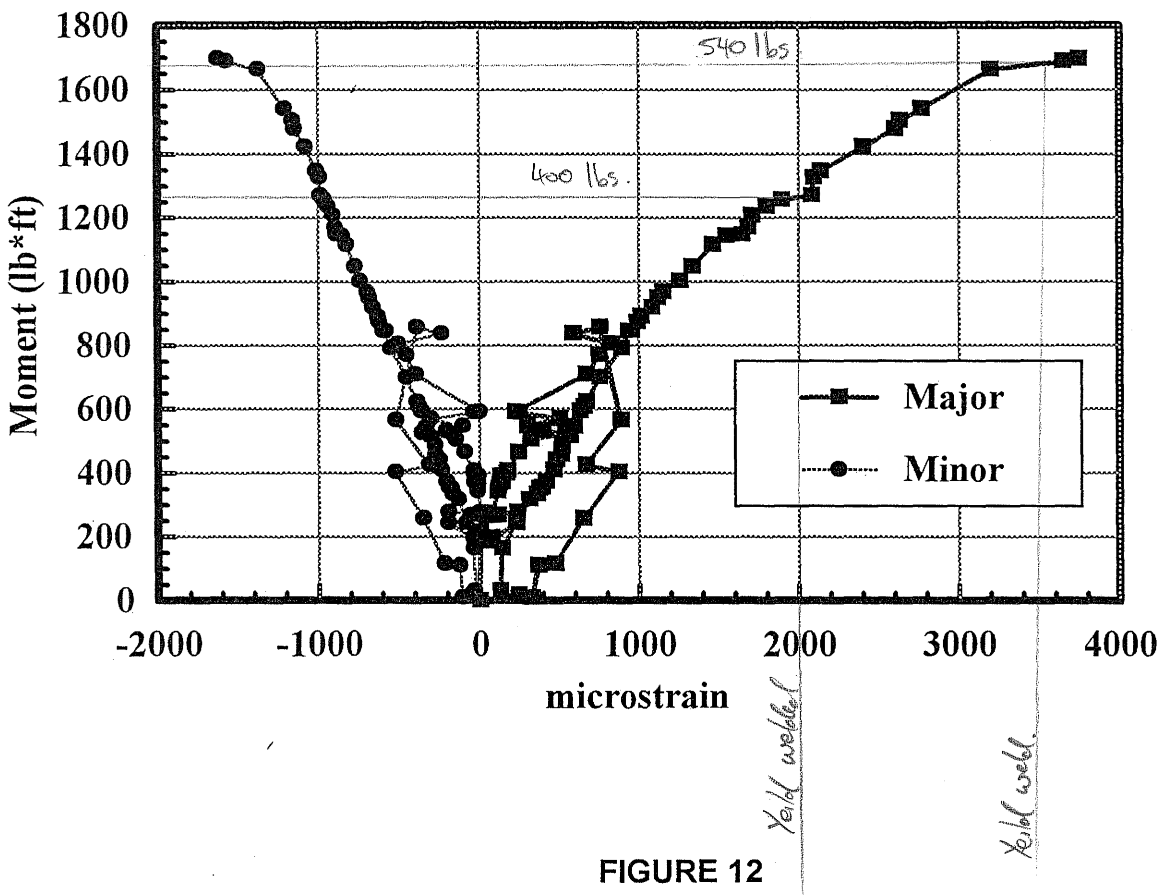


FIGURE 12

7.4 Test Specimen #4

Name	: Specimen "D"
*Material	: Aluminum-By Contractor
Outside Diameter	: 2.375"
Thickness	: 0.154"
Post heights	: 37.5"
Moment of Inertia	: 0.658 in^4.
Section Modulus	: 0.562 in^3.

Note: Since no data was available for this specimen, Aluminum 6061-T6 material properties were assumed.

Design/Service Loads:

Doesn't match graph.

Moment at the base of the post = 12,187.5 in.-lb (1,015.6 ft-lb)

Maximum Deflection at 325 lbs, $\delta_{exp.}$ = 0.96 in. Theoretical = 0.87"

Maximum Bending Stress at 325 lbs, $\sigma_{exp.}$ = 12,500 lb/in^2? σ_s = 21,686 psi

Yield Stress of post, σ_y = 40,000 lb/in^2.

σ_{exp} / σ_y = 31.3 % of the yield strength of the post.

Ultimate/Failure Loads:

σ_u = 42,705 psi

Ultimate load = 640 lbs.

Ultimate Deflection, $\delta_{max.}$ = 3.21 in.

Mode of Failure :

Failure of weld and post at base plate (See Figure 13 below)

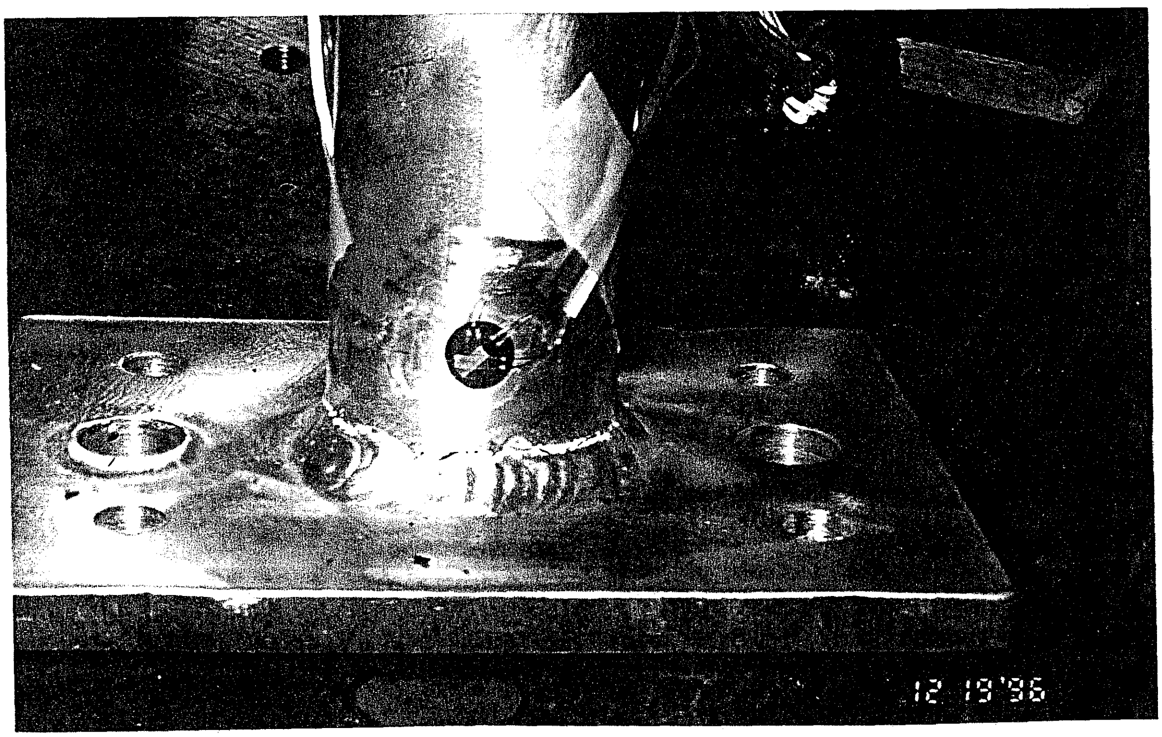


FIGURE 13

Moment vs Load Deflection

D-Contractor
2 3/8" o.d.
.154" thick

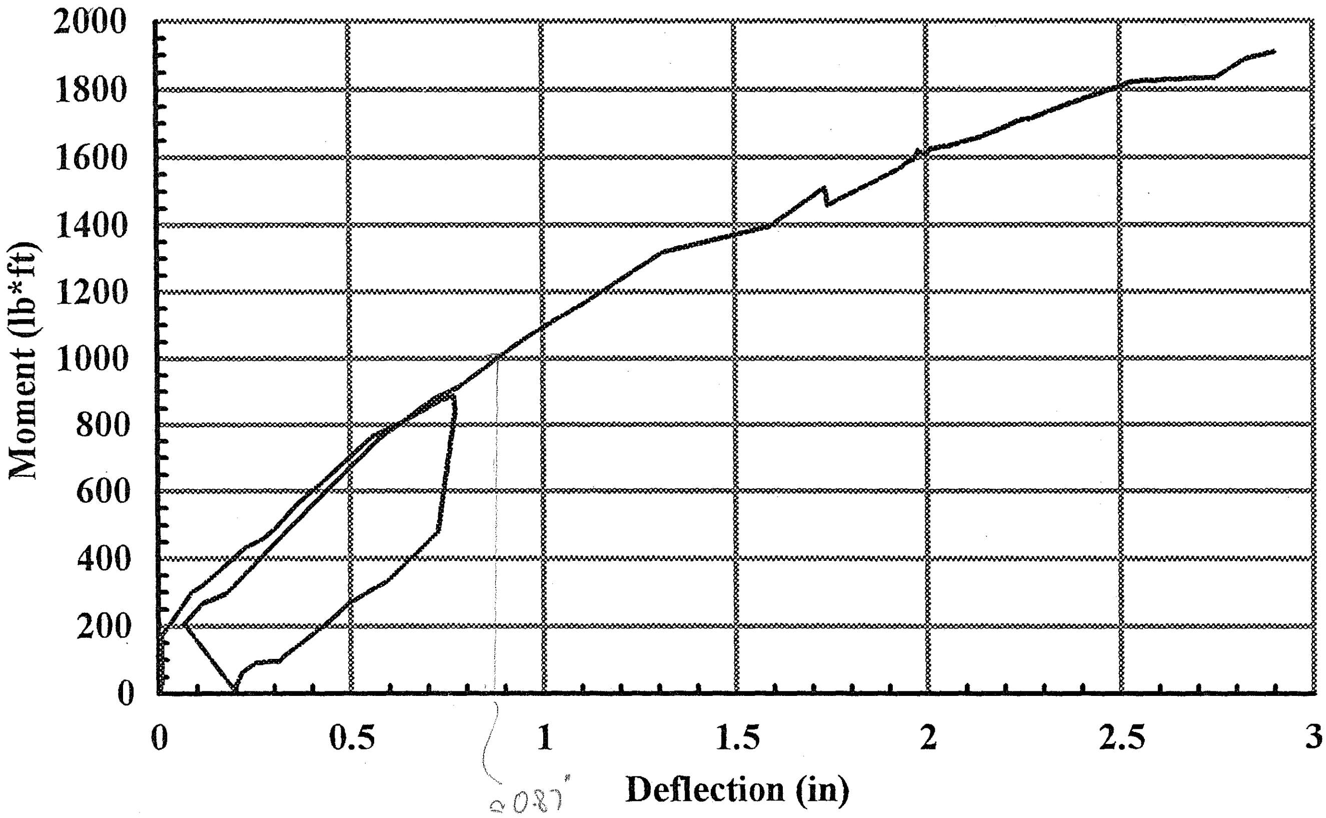


FIGURE 14

Primary strains
Rosette 2

D-Contractor
2 3/8" o.d.
.154" thick

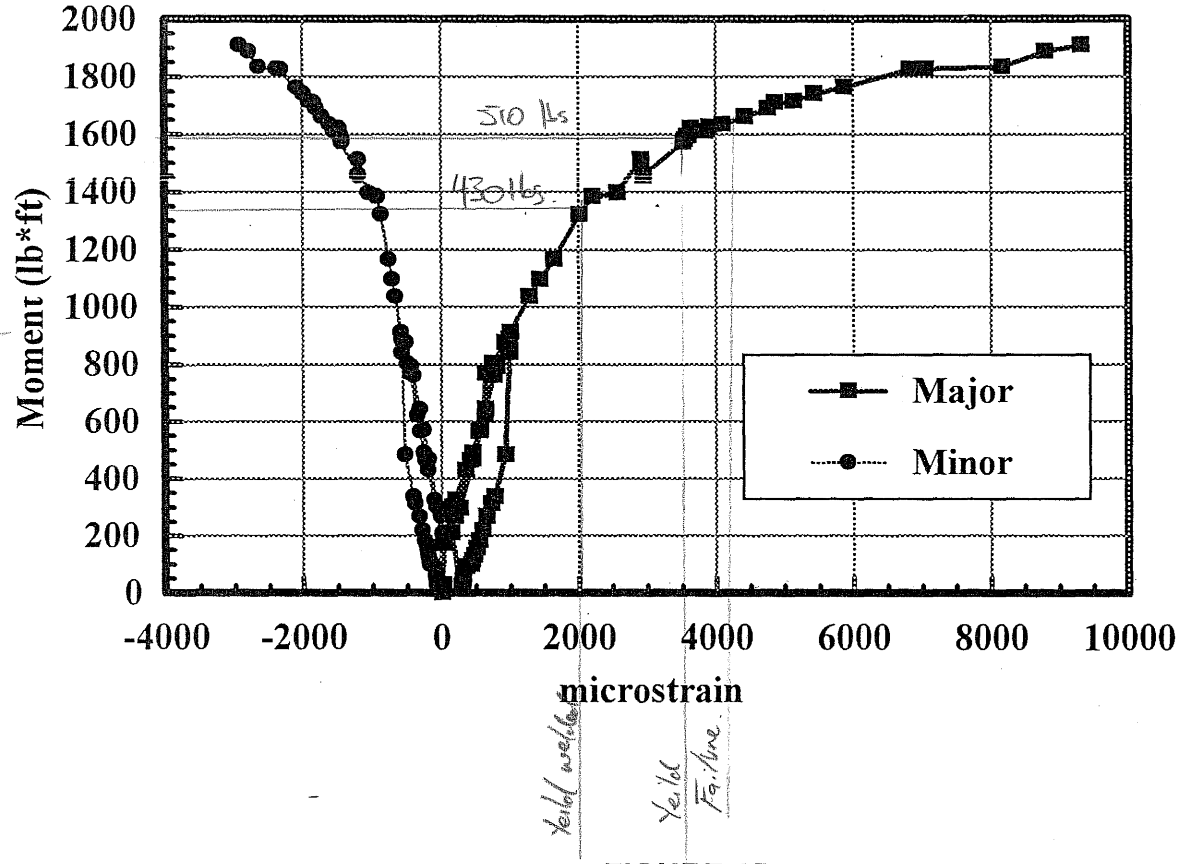


FIGURE 15

8. CONCLUSION AND RECOMMENDATION

The test results showed that all the tested specimens were in full compliance with the AASHTO and FDOT loading requirements. Figure 16 showed all the tested posts.

It is recommended to test two FDOT standard railings with three posts each. This full scale testing will simulate the actual field condition and look more into the overall behavior of the railing.

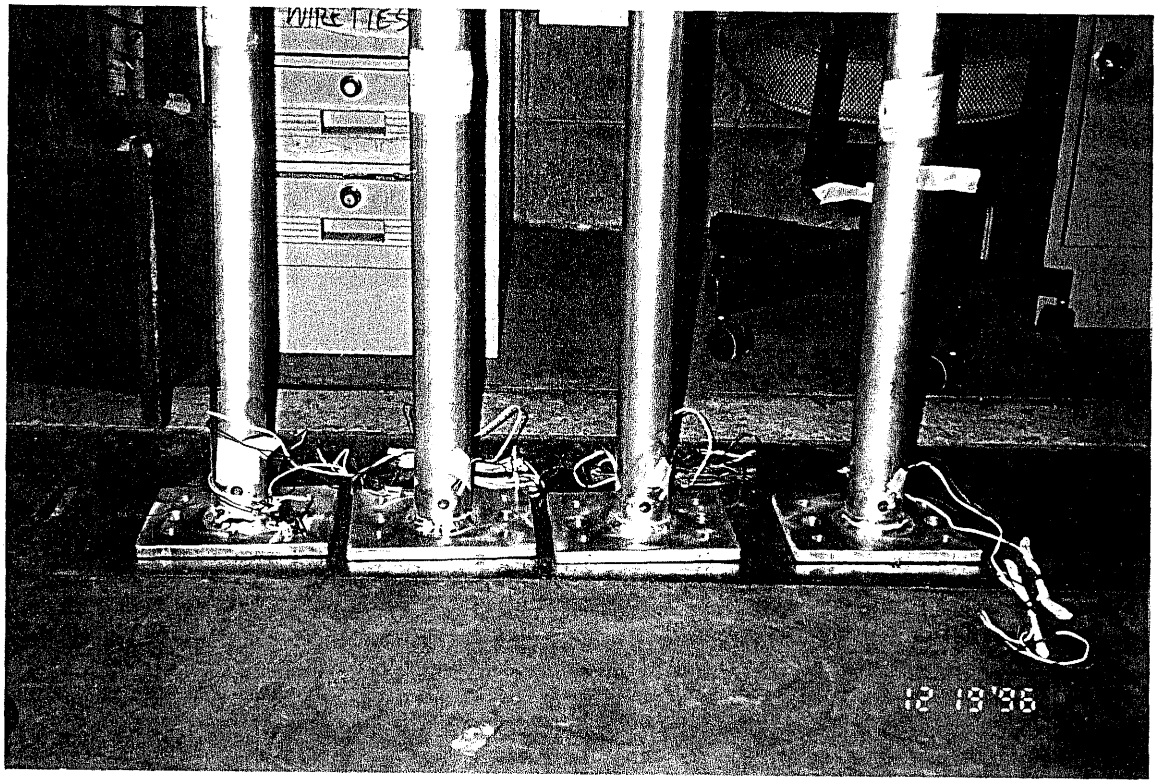


FIGURE 16

9. ACKNOWLEDGMENTS

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