

Lateral Load Test on Driven Pile Footings

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The October 17, 1989 "LOMA PRIETA" earthquake provided an ideal time and situation to perform for the first time, at no installation cost, a full scale lateral load test on a group of driven piles in typical bridge footings at the Cypress Street Viaduct. Since these foundations were no longer going to be used, we were able to load them laterally to failure and record load versus deflection.

Testing was performed at two different locations. Location #1 consisted of 60'± long piles in a clayey (bay mud) material, and location #2 consisted of 15'± long piles in sandy silt.

Preliminary results were very encouraging. Lateral pile capacities were observed at ¼" deflection, which greatly exceed our Bridge Design Specifications criteria. Reduced data produced a range from 17 kips to approximately 26 kips per pile in these two soil types.

Considering that we use 5 kips/pile in today's design criteria for this type of pile, one can readily see that if this number were increased to just 10 kips, the number of piles required for lateral forces would be significantly reduced, thereby achieving an appreciable reduction in cost for foundations of this type.

Pile capacities are correlated with appropriate soil parameters for the two soil types. Bridge Design Specifications are being proposed to take advantage of the increased lateral load capacities obtained in this research project.

INTRODUCTION

For the past fifteen years, Caltrans foundation pile designs for lateral forces have been based on full scale testing of single piles in pre-drilled holes with a two layer soil system consisting of a compacted embankment on an underlying natural deposit of silt or clay [1]. An earlier study for a sandy soil at Occidental Drive Overcrossing in Sacramento was published in "Lateral Resistance and Deflection of Vertical Piles, Interim Report #1 [2]. Several experimental studies concerning the behavior of piles and pile groups subjected to lateral loading have been conducted at the University of Houston Pile Test Facility. None of these tests, however, loaded the piles to failure.

To load the piles to failure at the Cypress Street Viaduct, there were two points to consider:

- 1) Ultimate capacity of the pile
- 2) Capacity of jacking frame

Since the maximum number of piles under the footings to be tested was seventeen (17) and our Bridge Design Practice specifies an ultimate lateral resistance of 40 kips per pile for earthquake loads, the Caltrans Substructure Committee assumed that a minimum force of 680 kips would be needed to fail the piles; furthermore, to make sure the jacking frame would not fail, the Committee agreed on a maximum force of 1500 kips for the frame to assure its structural integrity throughout the testing. Christie Constructors, Inc. was chosen to provide a calibrated jack and to design the jacking frame (Figure 1).

FOUNDATION INVESTIGATION

A foundation investigation was completed at the site in February 1990 by the Engineering Geology Branch of the Office of Transportation Materials and Research. Rotary sample borings of 4" were drilled at both test locations. Eight samples from the boring near Bent #97 and two samples from the boring near Bent #61 were analyzed.

Boring log (B-6) near bent #97 is shown in Figure 8, and boring log (B-4) near bent #61 is shown in Figure 9.

TEST PROCEDURE

Bent #97:

- 1) Excavate between footings to expose inside face (perpendicular to centerline of bent).
- 2) Locate centerline of bent on each footing and mark.
- 3) Set a transit on one mark, sight at the other and turn 90 degrees to set a hub at some distance (10'±), then rotate the eyepiece 180 degrees to set another hub.
- 4) Repeat process for each footing.
- 5) Place jacking frame between the right and center footing.
- 6) Dry pack all voids between end plates and face of right footing to assure full bearing.
- 7) Provide additional steel plates between jacks and face of center footing for a tight fit.
- 8) Fix measuring tapes on the footings parallel to centerline of bent to measure deflections.
- 9) Perform Phase I test, then release jacks (Figures 3 and 4).
- 10) Place bracing frame between the left and center footing; provide additional plates between end plates and face of footing for a tight fit.
- 11) Perform Phase II test (Figure 5).

Bent #61:

- 1) Eliminate the passive pressure created on the other side face of the footing.
- 2) Eliminate the dry pack and use steel plates throughout.
- 3) Perform Phase I test only.

CONCLUSION

Caltrans Bridge Design Specifications presently specify 5 kips of lateral resistance at ¼" deflection with a standard penetration resistance value, N of 10 for a (12" flange) steel pile or a 12" driven concrete pile. This value appears to be extremely conservative as borne out by the Cypress tests (see Summary Table).

On an interim basis, until more site tests at other locations and in other soils can be made, it was recommended that the Caltrans Specifications be increased to 10 kips lateral resistance for the above conditions. Caltrans specifications are being revised accordingly.

Further tests at other sites using this jacking frame are being planned one of which is at the Terminal Separation replacement in San Francisco.

SUMMARY TABLE OF RESULTS

| <i>Location</i> | <i>Load/Pile @ 1/4" Deflection</i> |
|-------------------------|---|
| Bent #97 Center Footing | 17.7 kips (Phase I) |
| Bent #97 Right Footing | 20.9 kips (Phase I) and 25.6 kips (Phase 2) |
| Bent #97 Left Footing | 32.9 kips (Phase 2) |
| Bent #61 Center Footing | 24.7 kips |
| Bent #61 Right Footing | 25.0 kips |

REFERENCES

- [1] Yee, Wilfred S., "Lateral Resistance and Deflection of Piles – Final Report – Phase I," State of California, January 1973.
- [2] Yee, Wilfred S., "Lateral Resistance and Deflection of Vertical Piles, Interim Report #1," State of California Business and Transportation Agency, Department of Public Works, Division of Highways, Bridge Department, R&D Report No. 6-71, September 1971.

Table 1. Calibration of Jacks

| Pressure Gage (psi) | Load (kips) |
|---------------------|-------------|
| 100 | .0 |
| 1,000 | 217 |
| 2,000 | 445 |
| 3,000 | 675 |
| 4,000 | 905 |
| 5,000 | 1,140 |
| 6,000 | 1,370 |
| 7,000 | 1,602 |
| 8,000 | 1,830 |
| 8,800 | 2,010 |

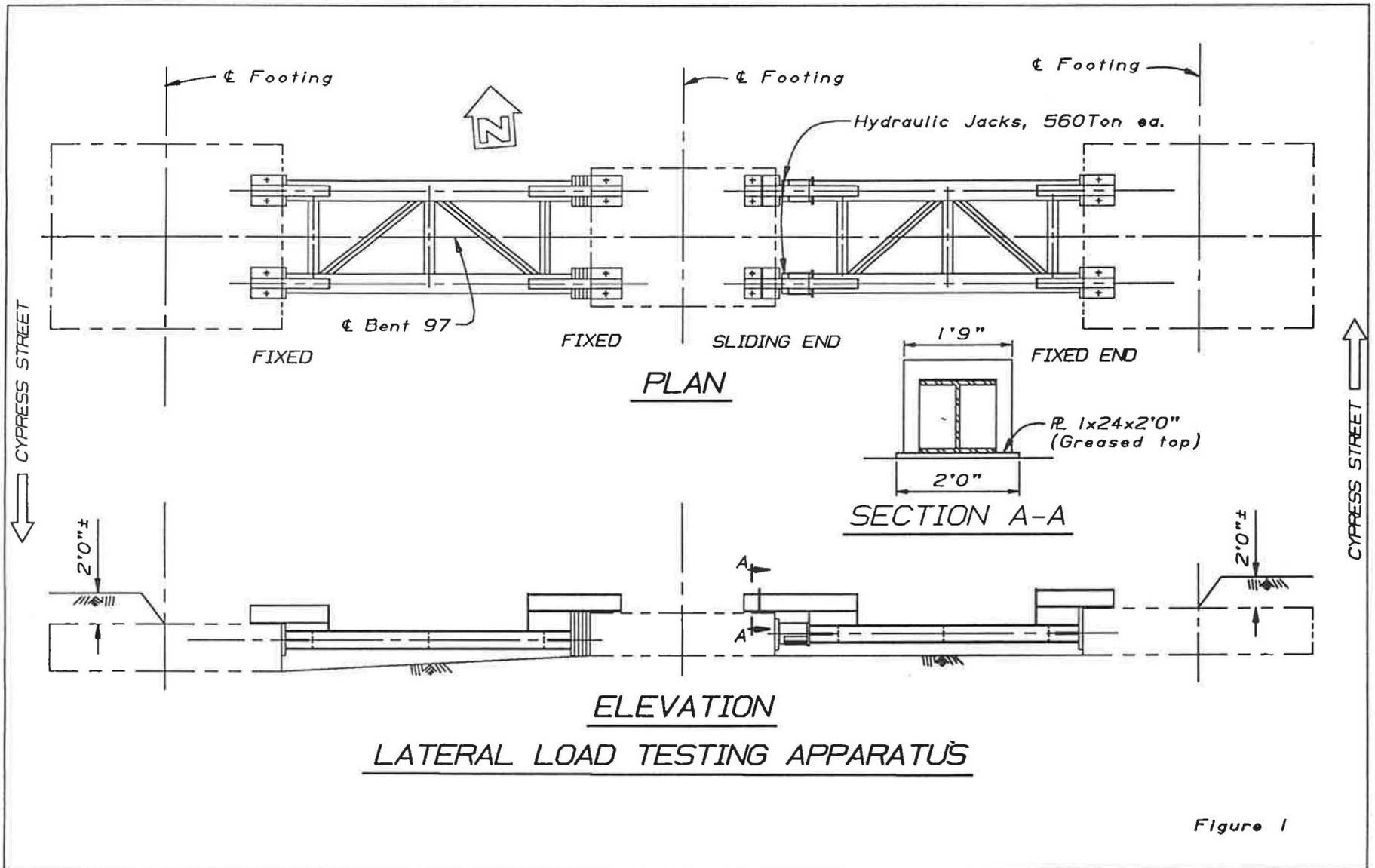
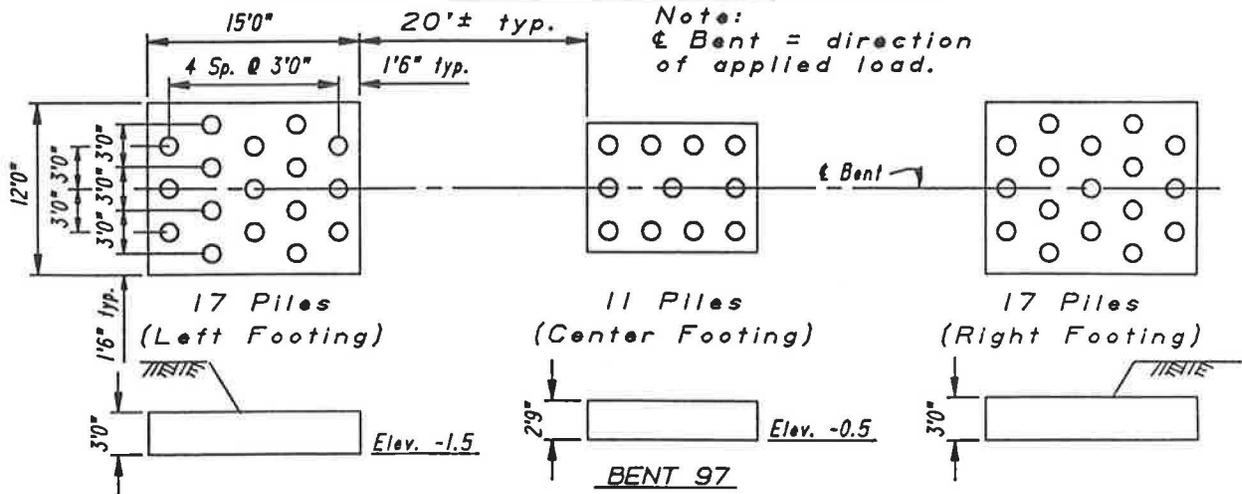
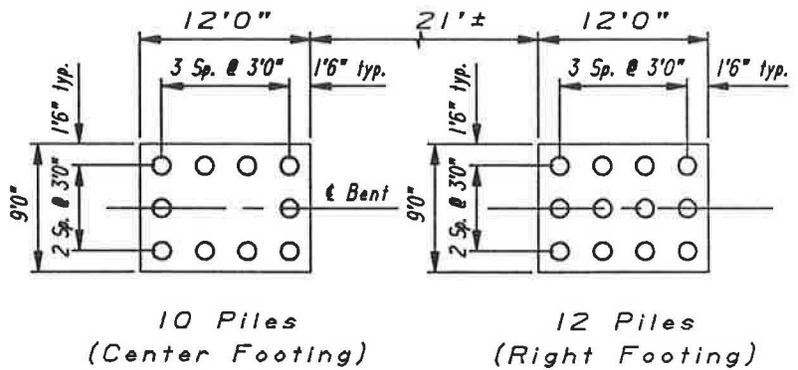


Figure 1

FOOTING AND PILE LAYOUT

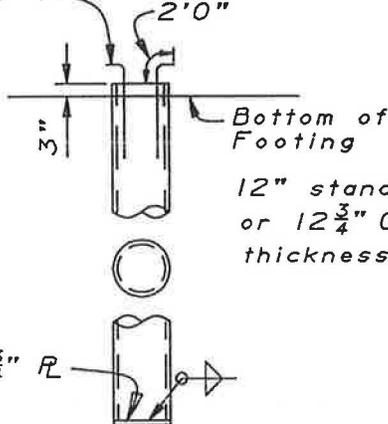


Left footing
 not tested.



TYPE OF PILE TESTED

#6 dowels x 4'6"
 tot. 4

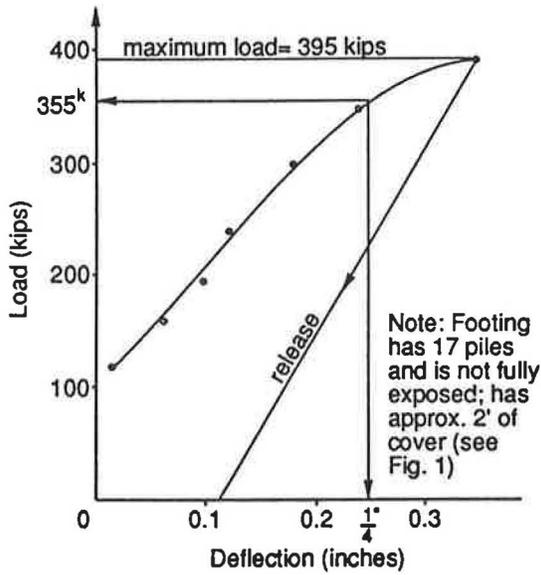


12" standard pipe (thickness = 0.219")
 or 12 3/4" O.D. welded steel pipe (Min.
 thickness No. 7 gage)

Note:
 Pile is, filled with
 Class A P.C.C.

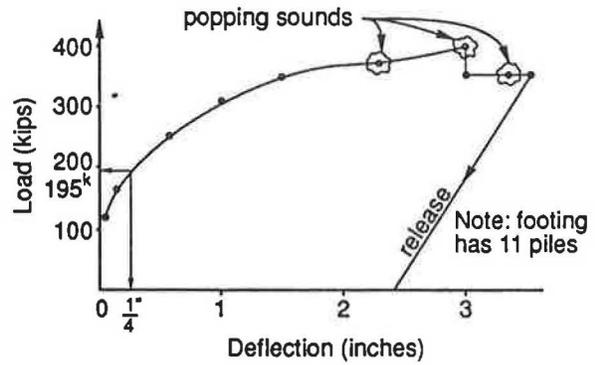
Fig. 2

Phase I Testing



Load vs. Deflection Curve for Bent #97 "Right" Footing

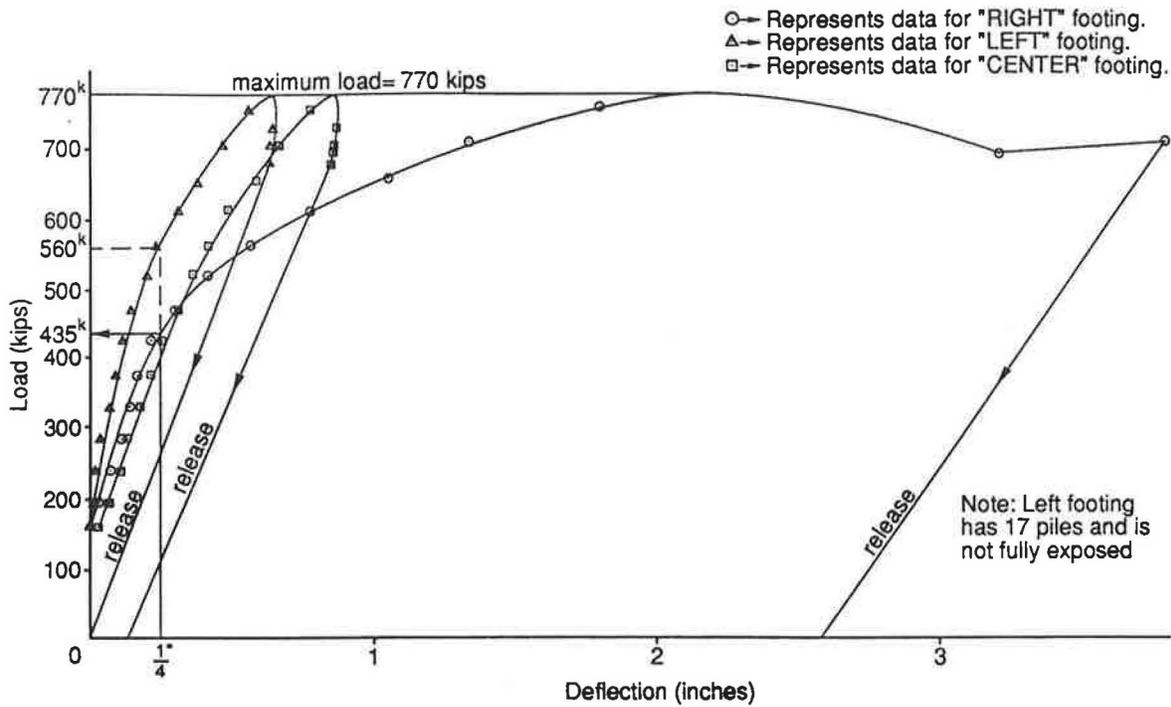
Fig. 3



Load vs. Deflection Curve for Bent #97 "Center" Footing

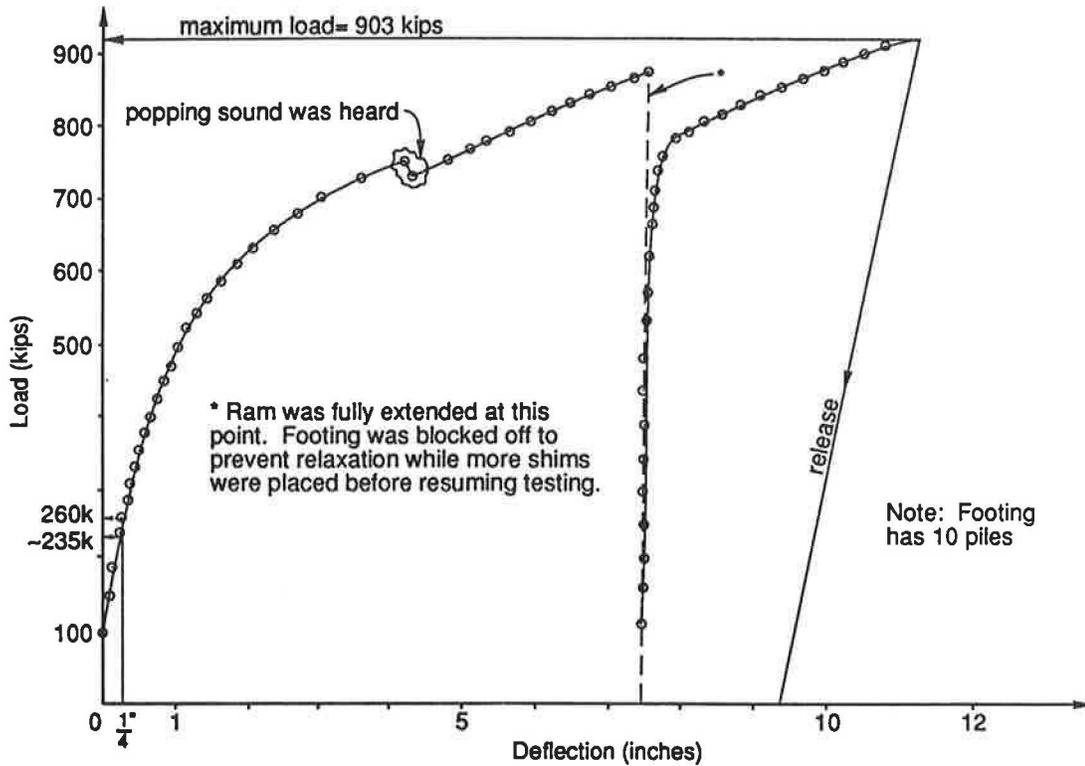
Fig. 4

Phase II Testing



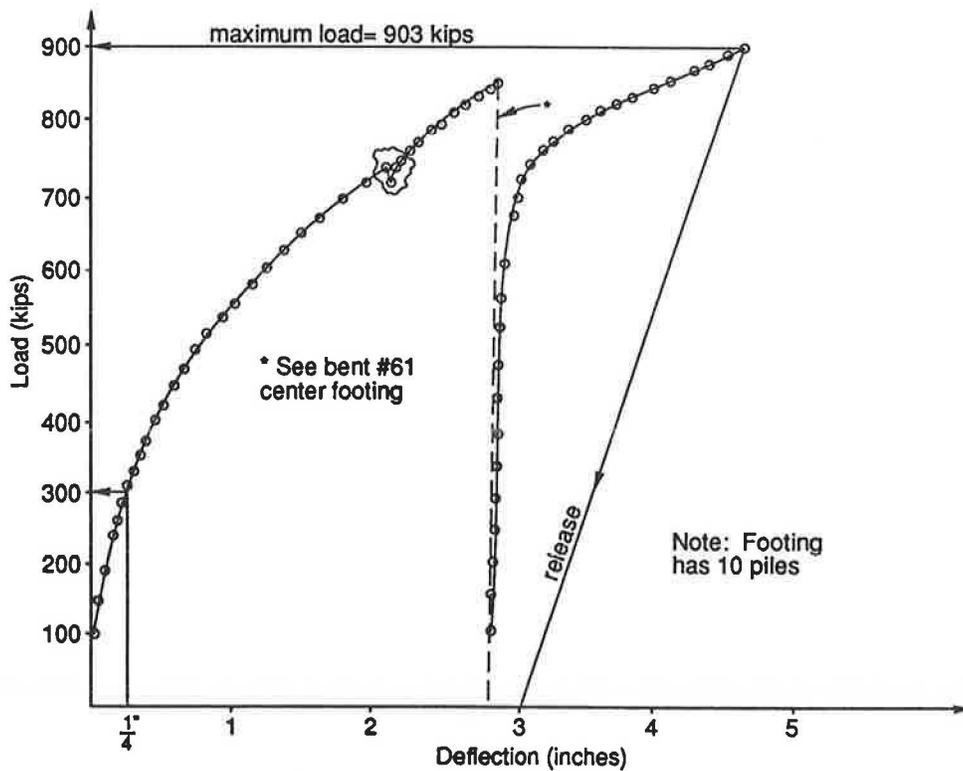
Load vs. Deflection Curve for Bent #97 Footings

Fig. 5



**Load vs. Deflection Curve
for
Bent #61 "Center" Footings**

Fig. 6



**Load vs. Deflection Curve
for
Bent #61 "Center" Footings**

Fig. 7