FULL SCALE STUDY OF GUARD RAIL ANCHORS

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THESIS

Full Scale Study of Guard Rail Anchors

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by

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PREFACE

The work of this thesis is a continuation of H. I. Bacon's "Experimental Investigation of Michigan State Highway Guard Rail Anchorages" and J. F. Bovill's "Guard Rail Anchorage Investigation". The procedure of the experiments is similar to Mr. Bacon's and Mr. Bovill's, but it was carried on with full scale anchors under actual field conditions.

I would like to acknowledge and thank Mr. E.A. Finney and Mr. L.D. Childs of the Testing and Research Division, Michigan State Highway Department, for their cooperation and advice in this project.

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FULL SCALE STUDY OF GUARD RAIL ANCHORS

Guard rail anchorage was suggested to me as an excellent topic for a thesis. This work is now under investigation by the Michigan State Highway Department Research Laboratory, and as I wanted to do something of practical value for future reference, I selected this subject.

PURPOSE

The guard rail anchorage investigation is now in the third and final stage, full scale pullouts. The purpose of this investigation is to verify or to disclaim, in full scale, the experimental stages carried on by Mr. Bacon and Mr. Bovill. It is also to determine if the pull out resistance of special anchors is of a greater value so that it is more economical to use them in place of the common deadman, a wooden post, now used by the Michigan State Highway Department.

HISTORY

Many articles have been written on various phases of guard rail anchorage; but there is still a great deal of work to be done on this subject. Dr. Wilhelm Buchholz, a German experimentalist, wrote an article entitled "Soil Resistance of Anchor Plates". His work consisted of testing different sizes of square plates buried in sand at depths of 1 to 4 feet with a horizontal pull through a wall.

D. C. Hubbard, A.B. Change Company engineer, worked on full scale metal anchors. His various anchors, the screw, expanding, rock, pyramid cone types, were buried from 3 to 7 feet invarious type soils. The anchors were pulled at a 45° angle by means of a pole, block and tackle, spring scales and a caterpiller tractor. The pull out values did not vary lineally with the depth of burial and a 15% variation due to the different types of soil conditions, was found in the results.

R. T. Haggerstrom did some more investigation on anchors for his thesis entitled "An Experimental Study of Special Anchors in Sand and Clay". The anchors were buried at 8 inches and 4 inches in sand and clay. They were pulled 45° and 60° angles. An angle of 45° was found to have the most resistance to pull out. Clay was found to be more resistive to impact loads than the sand.

The thesis, "An Experimental Investigation of Michigan State Highway Guard Rail Anchorages", by H. I. Bacon is on the primary or experimental stage of guard rail anchors. The anchors were square, round, oval, and log type buried at a depth of 12 inches in sand. The cable was placed over a pulley and weights were loaded in a bucket at the end of the cable, till failure occured in the sand. The oval anchor was found to have the most resistance to pull out.

J. F. Bovill also experimented with anchors and wrote a thesis entitled "Guard Rail Anchorage Investigation". A number of curves were drawn from the data compiled by Mr.

Bovill. These curves were entitled "Effect of Anchor Area on Pullout Value", "Effect of Depth of Anchor on Pullout Value", and the "Effect of Moisture Content on Pullout Vallue". This entire work was done on the oval anchor.

With this experimental work completed; the specific purpose of this investigation is to do full scale work and varify or disclaim the findings of the primary experiments.

MATERIALS

Figures 2,3, and 4 show the type of concrete anchors used in this investigation. A common wooden post, shown in Figure 7, was also used. All Anchors are shown as they were placed in the trench in Figure 7.

The anchor specifications are as follows:

	Type	Dimension inches	Area Square inches
1	Circular - Concrete	27.1 dia x 6	576.5
2	Oval - Concrete	26.6 x 15 dia x 6	575.7
3	Square - Concrete	24x 24 x 6	576.0
4	Log - Wood	72 x 8 dia	576.0

Anchor (3) and (4) are models of anchors as specified by the Michigan State Highway Department.

The anchors were buried in sand found near the Michigan State Highway Maintenance Garage at Charlotte, Michigan.

Figure 1. Pull out apparatus

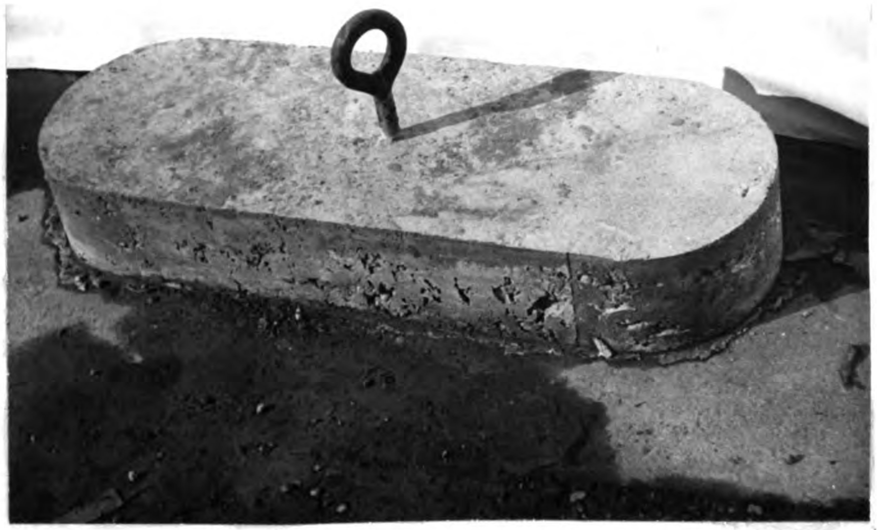


Figure 2. Oval Concrete

Figure 3. Circular Concrete

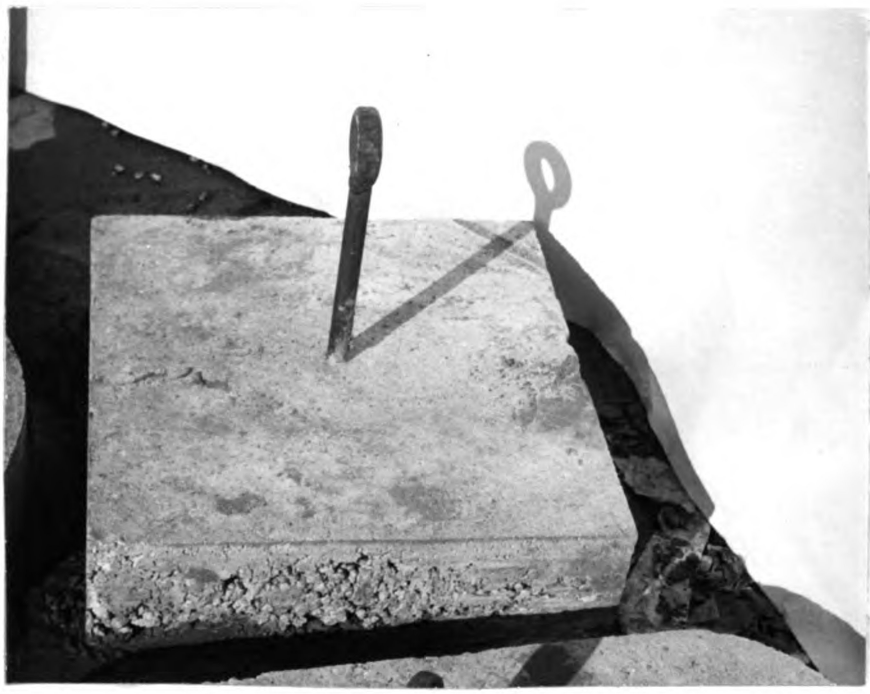


Figure 4. Square Concrete

EQUIPMENT

The anchors were pulled out with the apparatus as shown in Figure 1. This piece of equipment was made from two 9 inch channels and some old lengths of grader blades welded together in a right angle with a 45° bar between them. As the hydraulic jack was pumped, it moved the 45° angle bar at right angles to the cable. With this mechanical advantage the anchors were pulled until failure occurred.

The trench was dug by a small dragline and the sand was shoveled back in layers and tamped by an air hammer as shown in Figure 8. The pullout indicator (Figure 5) was made from a common 1 inch steel bar, bent to form inch circles at each end to hook cables to. Strain gauges were put on the bar and the pullout bar was calibrated in a universal testing machine. The strain which was placed on the bar was recorded by the S.R.4 portable strain indicator (Figure 6).

Figure 5. Pull out bar.

Figure 6.
S.R.4. Portable
Strain Indicator

PROCEDURE

A trench was dug and the anchors were placed in such a manner that the eye bolts would be at a 45° angle (Figure 7). Long cables were then placed on all the anchors to be connected to the pull out bar. Layers of sand of approximately 1 foot were added. Each layer was compacted with an air hammer until the center of gravity of all the anchors was covered with 4 feet of sand.

The anchors were then ready to be pulled out of the trench. The apparatus was set up as shown in Figure 1. with the cable from the anchor attached to the pull out bar and the bar attached to the pulling mechanism.

The following data recorded:

1. Force needed to cause ground failure
2. Movement of sand (recorded photographically)

Figure 7. Anchors as placed in the trench.

Figure 8. Trench digging and tamping apparatus.

DATA

Anchor Tested

Log.

Conditions

Longitudinal axis horizontal and at 90° to cable.

No.		Pounds Pull Required for Failure
1		21,650
2		19,950
3		20,020
	Mean	20,540

Anchor Tested

Oval Concrete.

Conditions

Longitudinal axis horizontal and at 90° to cable.

No.		Pounds Pull Required for Failure
1		20,700
2		23,850
3		23,010
	Mean	22,520

Figure 9.
Ground failure
caused by
oval anchor.

Figure 10. Ground failure caused by log.

DATA (continued)

Anchor Tested

Circular Concrete.

Conditions

Circular face 90° to cable.

No.		Pounds Pull Required for Failure
1		19,880
2		21,150
3		19,300
	Mean	20,110

Anchor Tested

Square Concrete.

Conditions

Axis horizontal; face at 90° to cable.

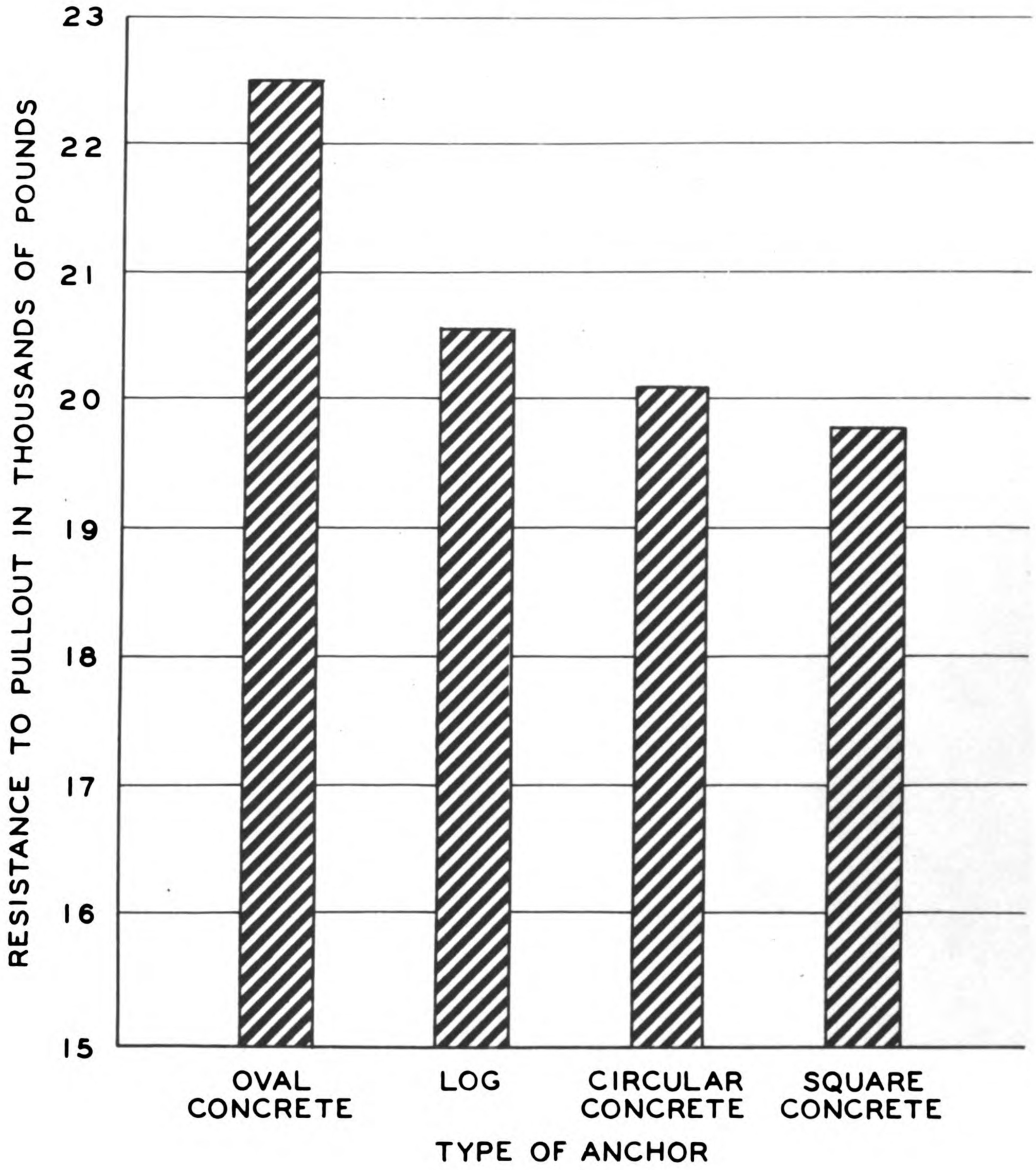
No.		Pounds Pull Required for Failure
1		19,990
2		18,870
3		20,480
	Mean	19,780

Movement of sand recorded in Figures 9, 10, 11 and 12 for each anchor.

Figure 11.
Ground failure
caused by
circular anchor.

Figure 12. Ground failure caused by
square anchor.

Figure 13



PULLOUT VALUES of DIFFERENT TYPES of ANCHORS

DATA (continued)

The oval anchor, which had the greatest resistance to pull out, was selected and further tests were made.

Purpose

To determine the relationships between the depth of burial of the oval anchor and the pull out value.

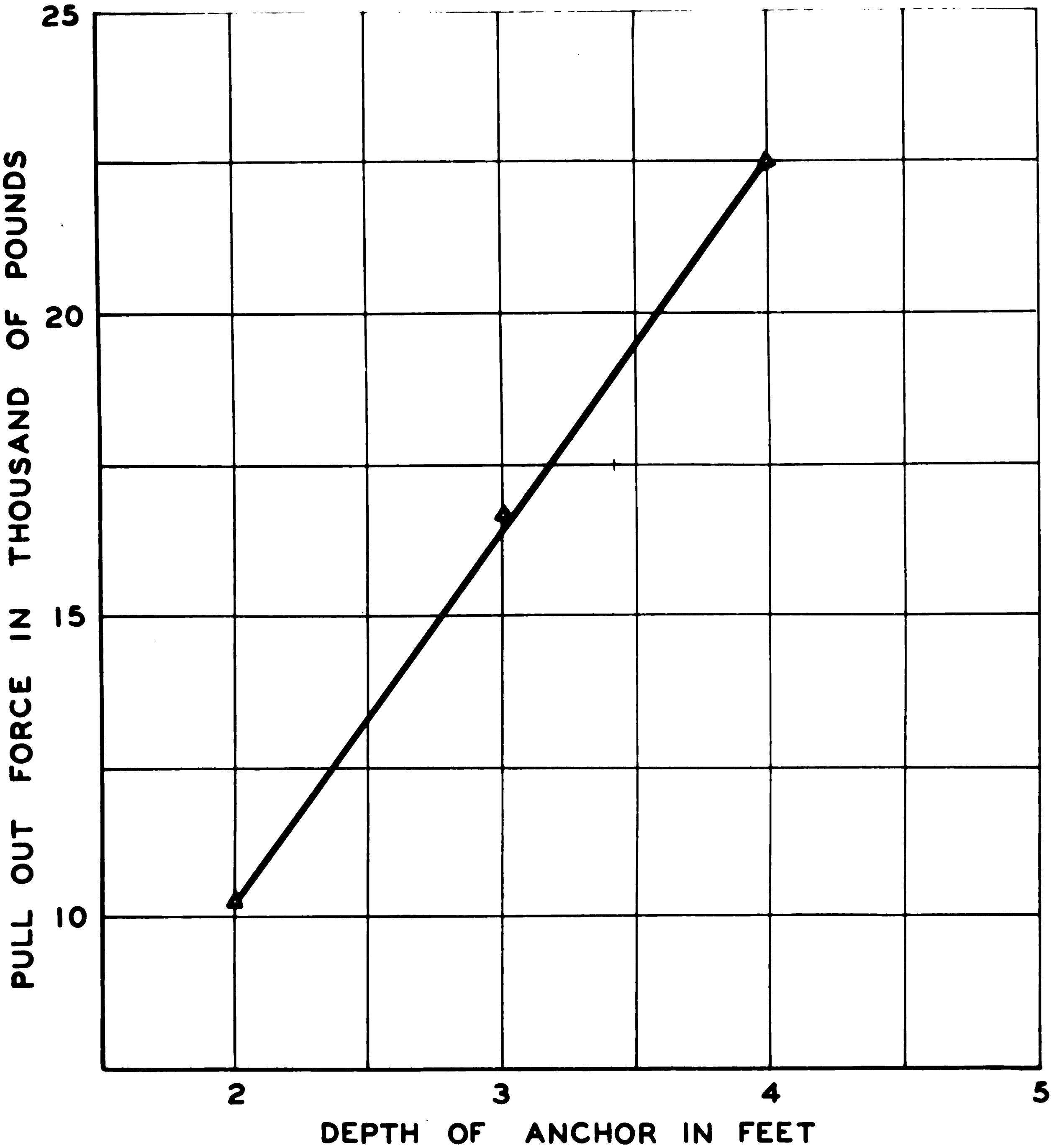
Conditions

Longitudinal axis horizontal and at 90° to cable.

Burial Depths in Feet	Pounds Pull Required for Failure
2	10,250 #
3	17,180 #
4	22,520 #

Graph of Depth Vs. Pull Out Figure 12.

Figure 14



RELATION *of* DEPTH *of* OVAL ANCHOR *to* PULL OUT VALUE

SUMMARY

The holding power of the various types of anchors given in the data and shown in the bar graph (Figure 13) are very much in agreement with the scale model work. As this investigation was undertaken to varify the work done by H. I. Bacon; the results on this phase of experimentation can be called satisfactory. The oval anchor was found to have the most resistance to pull out, in full scale as it did in the primary investigation. Also the order of pull out values of the remaining anchors varied in accordance with data compiled by Mr. Bacon.

The Depth Vs. Pull Out graph (Figure 14) drawn from the data of this work was also in agreement with the graph of Mr. Bovill. In both graphs the deeper the anchor was buried, the greater resistance to pull out it had, as would be expected. Mr. Bovill's graph was a straight line; the graph from the full scale experiment was very nearly a straight line.

The small difference between the pull out values of the special anchors and of the log does not constitute a change in present highway practice. At first glance one could say the oval anchor should be used in place of the log, because of its greater pull out resistance. Further investigation, because of the cost of materials, time of curing, and great weight, proves that it is not economical to use the special anchors in place of the common wooden deadman.

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