National Cooperative Highway Research Program

RESEARCH RESULTS DIGEST

DIGEST 124 - NOVEMBER 1980

A Modified Foundation for Breakaway Cable Terminals

A digest of recent developments on breakaway cable terminals by M. E. Bronstad, Southwest Research Institute, San Antonio, Texas.

THE PROBLEM AND ITS SOLUTION

Research on breakaway cable terminals (BCT) for guardrails and median barriers was carried out at Southwest Research Institute from 1972 to 1975 under NCHRP Project 22-2, "Traffic Barrier Performance and Design." The findings were published in NCHRP Research Results Digests 84(1) and 102(2). In the past 5 years, the BCT has gained widespread acceptance, as evidenced by the fact that a total of almost 100,000 are now in use as guardrail end treatments in more than 40 states. Available accident information indicates that the BCT performs well when installed properly. Installation details can be found in "A Guide to Standardized Highway Barrier Rail Hardware"(3).

The purpose of this Digest is twofold: (1) to recommend a modification to the foundation detail for the timber post version of the BCT and (2) to reemphasize a feature of the BCT which has been shown by accident experience to be crucial to proper performance.

The NCHRP staff and the Southwest Research Institute researchers are frequently contacted by agencies asking the following questions about the BCT:

- How can the cost of the concrete footings for the breakaway posts be reduced?

- How can removal of broken timber posts from the concrete footings be facilitated?

- How can the guardrail BCT be adapted for use where site conditions do not allow the 4-ft flare specified in the recommended design?

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The first question arises because the placement of small quantities of concrete at many sites can be uneconomical. The fact that the second question comes up so often is an indication that BCTs are being hit and that the posts are breaking away as intended. There is no answer to the last question on the basis of available research results. Accident experience has confirmed the expectation that, when the guardrail BCT is not flared, vehicles are speared by the straight W-beam rail in head-on impacts. Until a solution to this problem is developed, the guardrail BCT should not be installed without the 4-ft flare.

The end post foundation for the BCT must be capable of anchoring the longitudinal force developed in the rail during oblique impacts in the length-of-need portion of the barrier, and, for head-on impacts, it must enable the post to break away at an acceptable level of resistance. The concrete footing normally used for the terminal post prevents excessive displacement in the soil and ensures that adequate resistance is developed for these two functions. But in many locations, casting a small volume of concrete can be inconvenient and costly, therefore alternative details are needed.

In NCHRP Research Results Digest 102, a steel post foundation detail that was evaluated by Southwest Research Institute using pendulum tests was recommended as an alternative to the concrete footing.

In 1978, the Illinois Department of Transportation developed the foundation detail shown in Figure 1, where the wood post is inserted into a driven steel tube. The Illinois DOT demonstrated the breakaway capacity of this detail by impacting installed posts with a truck. However, further investigation was needed to determine this foundation's capacity for development of the anchor cable loads. Because of the potential for solving the previously mentioned problems associated with cost and the removal of broken posts, the working plan for NCHRP Project 22-2(3) was modified in 1979 to include a limited study of the anchor strength of this detail. Dynamic tests were conducted using the Southwest Research Institute's pendulum facility; the detail was modified to produce acceptable test results; and the detail shown in Figure 2 is recommended as an alternative foundation for breakaway wood posts.

Test Program

Four pendulum tests were carried out. The initial test was performed on the foundation detail developed by the Illinois DOT as shown in Figure 1. The second and third tests were performed on the detail modified as shown in the inset of Figure 1. The fourth and final test was used to validate the performance of the recommended detail shown in Figure 2.

Test Procedures

The specimens were placed in soil as specified in TRB Circular 191[4] by drilling and backfilling with compaction. The pendulum mass was raised to the highest position permitted by cable slack in each case. (Prior to tests 3 and 4, the pendulum was modified to increase the drop height.) After the 4000-lb (1800-kg) pendulum mass is released, a force develops in the cable as it becomes taut. This force was measured by an accelerometer mounted on the mass to provide an indication of the horizontal component of the cable load.

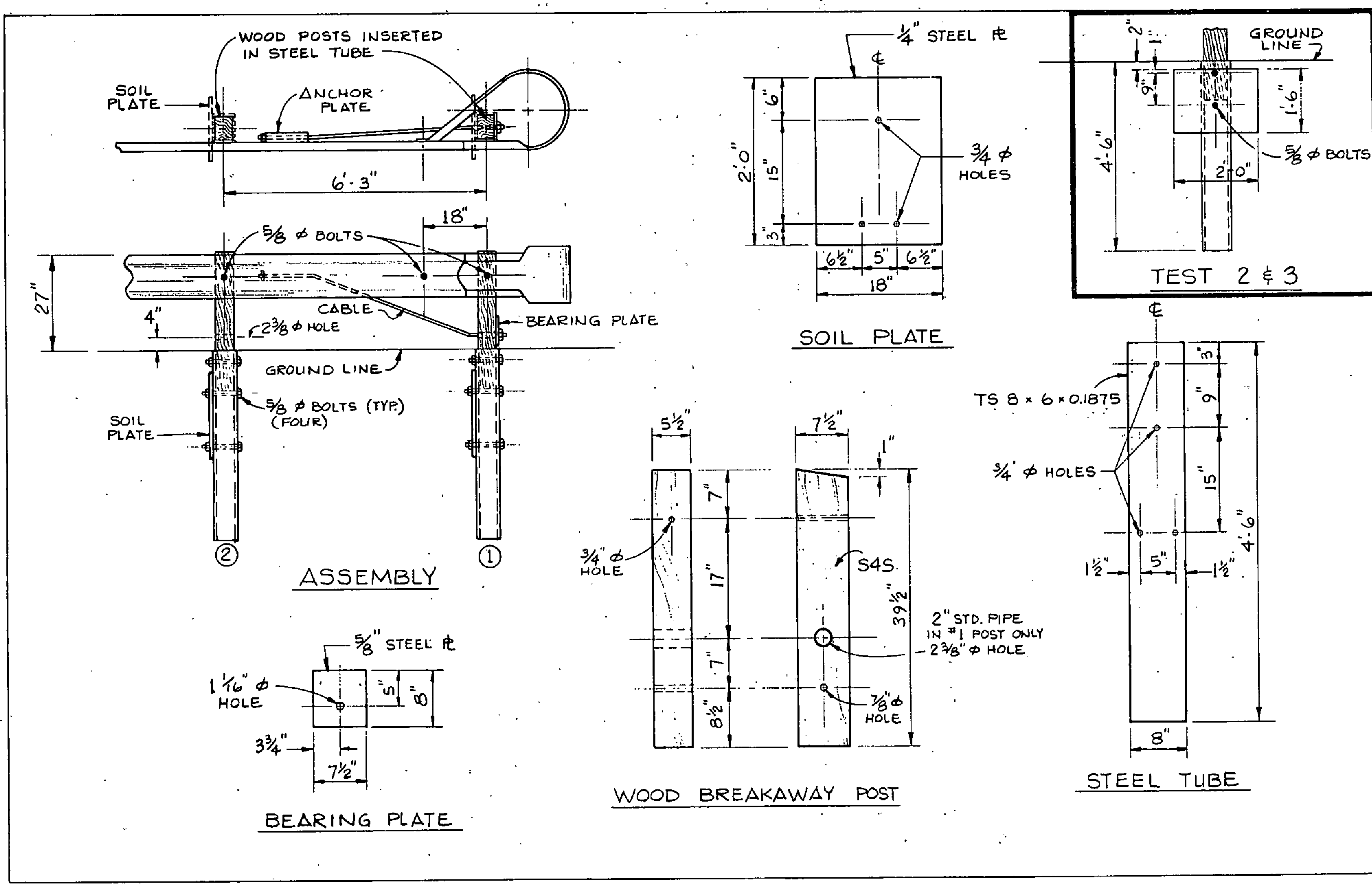


Figure 1. Illinois BCT alternate foundation.

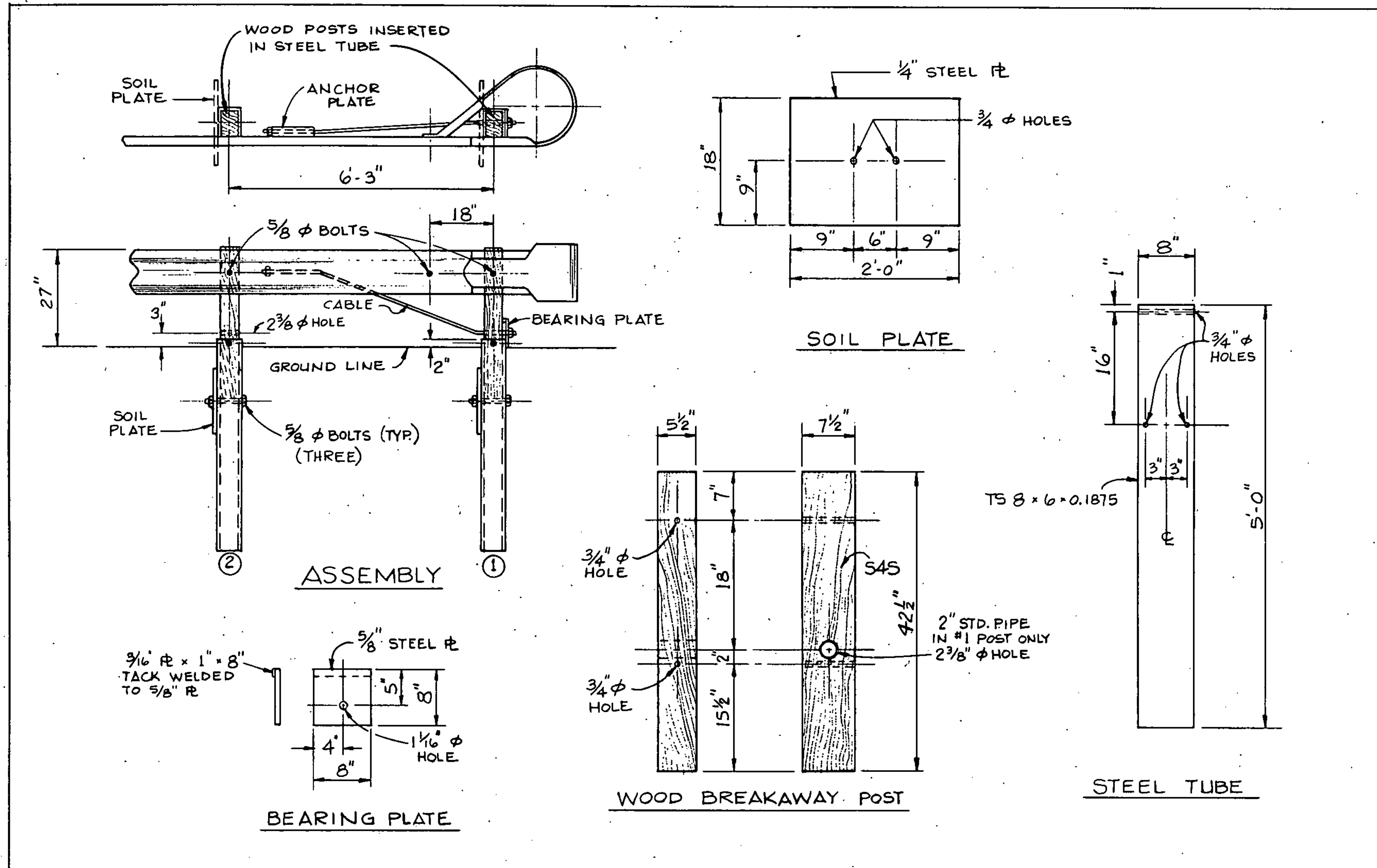


Figure 2. Recommended alternate foundation, wood post BCT.

Test Results

Results of the test program are summarized in Table 1; photographs of the posts after Tests 3 and 4 are included in Figure 3.

Test 1. Impact energy provided by the pendulum was sufficient to develop only a 17.6-kip (8,000-kg) horizontal cable force, far less than the cable strength of 42.8 kips (19,400 kg). The permanent 1.5-in. (40-mm) soil displacement was considered excessive for this load level.

Test 2. The foundation detail was modified by a 90° rotation of the soil plate, as shown in the inset of Figure 1. More load was developed, 22.0 kips (10,000 kg), with less soil displacement, 1.3 in. (35-mm), but the pendulum did not provide sufficient energy for a valid test.

Test 3. Modification of the test equipment to raise the pendulum drop height resulted in increased tension in the cable. In this test, the post fractured after reaching a maximum horizontal load of 36 kips (16,300 kg) and a soil displacement of 2.0 in. (50 mm). Unacceptable damage to the tube resulted, as shown in Figure 3.

Test 4. In the second modification to the Illinois detail, the foundation tube was extended 2 in. (50 mm) above grade to permit the bearing plate to overlap it (see Fig. 2). This is considered a significant improvement because the greater part of the cable load is transferred directly to the tube. Although the full breaking strength of the cable was not developed in this test, a cable load of 39 kips (17,700 kg) was successfully anchored with a residual soil displacement of 3 in. (75 mm).

FINDINGS

The results of Test 4 indicate that the foundation system shown in Figure 2 can develop a cable load of 39 kips (17,700 kg). This is less than the minimum breaking strength of the BCT cable assembly, 42.8 kips (19,400 kg), but is acceptable in view of the expectation that this foundation system will perform more effectively in service because of the considerable lateral support provided to the upper part of the post by the W-beam rail.

On the basis of the results of this test program, the system detailed in Figure 2 is recommended as an alternative to the concrete footing for wood breakaway posts.

APPLICATIONS

The breakaway cable terminal is being used extensively throughout the United States and has been found to be effective when it is installed as detailed in Figures 2 and 4 of NCHRP Research Results Digest 102. The breakaway plane of the posts must be at, or below, the specified elevation above grade (i.e., 2 in. for the steel post and 4 in. for the wood post), and the 4-ft offset flare must be used for the guardrail installation.

An alternative foundation system that precludes the concrete footing for the steel breakaway post was detailed in Figure 3 of Digest 102. Based on the dynamic tests reported herein, the alternative system shown in Figure 2 of this Digest is recommended for immediate application where it is desired to avoid the use of a concrete footing for the wood breakaway post. This system also should facilitate removal of broken posts after an impact.

It should be noted that, in a Federal Highway Administration sponsored study currently in progress at Southwest Research Institute, the performance of the BCT is being evaluated for impacts by mini-sized cars, and the results to date give cause for concern about the performance of cars in the weight range of approximately 1800 lb.

The NCHRP Projects Engineer responsible for NCHRP Project 22-2 is Dr. Robert J. Reilly, who can be reached at (202) 389-6741. Specific questions on the research may be addressed to the principal investigator, Mr. Maurice E. Bronstad at Southwest Research Institute (512) 684-5111.

REFERENCES

1. "Breakaway Cable Terminals for Guardrails and Median Barriers," NCHRP Research Results Digest 84 (March 1976).

2. "Modified Breakaway Cable Terminals for Guardrails and Median Barriers," NCHRP Research Results Digest 102 (May 1978).

3. "A Guide to Standardized Highway Rail Hardware," ARTBA Technical Bulletin No. 268-B, AGC Standard Form No. 131 (June 1979)

4. "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances," Transportation Research Circular 191 (February 1978).

TABLE 1

SUMMARY OF PENDULUM TESTS

Test No.	Test Article	Maximum Horizontal Force, kips*	Maximum Cable Force, kips*	Maximum Soil Displ., in.*
1	Illinois detail (Fig. 1)	17.6	18.7	1.5
2	Illinois detail - Mod 1 (Fig. 1)	22.0	23.4	1.3
3	Illinois detail - Mod 1 (Fig. 1)	36.0	38.3	2.0
4	Illinois detail - Mod 2 (Fig. 2)	36.8	39.2	3.0

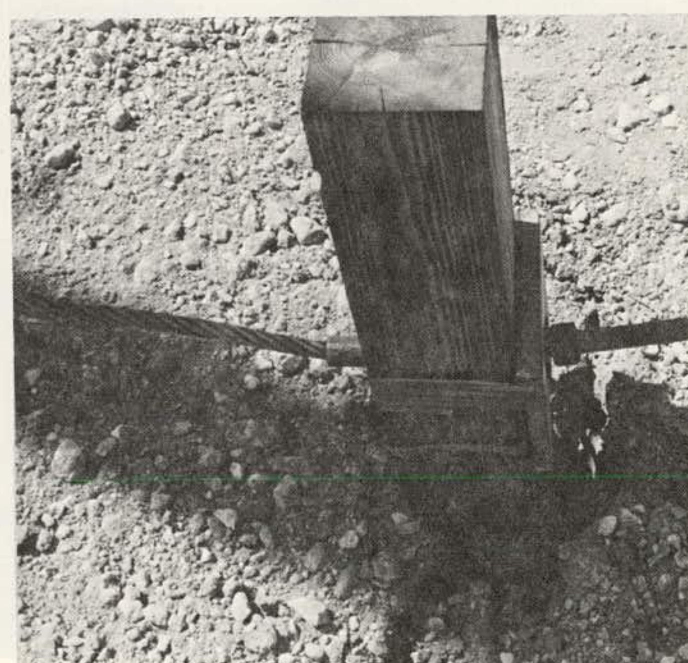
*Metric conversion: To convert kips to kg multiply by 454
To convert in. to mm multiply by 25.4

Hook set-up, Tests 3 & 4

(a) After Test 3

(b) After Test 3

(c) After Test 4



(d) After Test 4

Figure 3. Tests 3 and 4 photographs.

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