National Cooperative Highway Research Program

Research Results Digest

DIGEST 102 - MAY 1978

These **Digests** are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed and prior to publication of the project report in the regular NCHRP series, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may obtain, on a loan basis, an uncorrected draft copy of the agency's report by request to: NCHRP Program Director, Transportation Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418

Modified Breakaway Cable Terminals for Guardrails and Median Barriers

A digest of the latest information on breakaway cable terminals for guardrails and median barriers by M. E. Bronstad and J. D. Michie, Southwest Research Institute, San Antonio, Texas.

THE PROBLEM AND ITS SOLUTION

Approach ends of traffic barriers have been shown to be unduly hazardous to errant traffic. The W-beam in upright terminals has penetrated the passenger compartment in numerous end-on impacts, and ramped terminals have caused impacting vehicles to be launched, rolled, and tumbled. Under NCHRP Project 22-2, "Traffic Barrier Performance and Design," terminals for guardrails and median barriers were developed and evaluated by a series of crash tests. Named for a principle in their design, these devices are called breakaway cable terminals (BCT). NCHRP Research Results Digest 84 (March 1976) contained up-to-date findings on both the guardrail and median barrier BCT devices. Since that time, some 30 states reportedly have adopted the guardrail BCT as a standard (Fig. 1). Use of the median barrier BCT has not been nearly as widespread, but successful performance has been reported.

This Research Results Digest is intended to provide an update on developments during the past two years. Specifically, several problems have been reported both in service and in subsequent experimental programs, including:

- Difficulty in removing the fractured wood post from the concrete footing.

- Excessive cost of some BCT components.

- Unreasonable cost of concrete footings at rural locations.

- Snagging of a subcompact vehicle's under side by the steel-post BCT design.

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• Lack of requirement in several state standards that the terminal be flared as recommended.

Work reported by the California Department of Transportation (Caltrans), the Texas Transportation Institute, and the Southwest Research Institute has led to solutions of specific problems and to certain improvements. This Digest provides revised drawings that reflect the best available information on the BCT devices.

FINDINGS

The items of emphasis in this document include:

• Changes in the guardrail BCT drawings reflecting improvements developed by Caltrans.

• Alternate footings for BCT devices and suggested details.

• Modifications to the steel-post BCT design to eliminate vehicle underside snagging.

• Restatement of the need for adequate flaring of the guardrail BCT.

Caltrans Modifications

Engineers at Caltrans were concerned about removal of broken wood posts and the cost of some anchorage components. It was found that placing sheetmetal

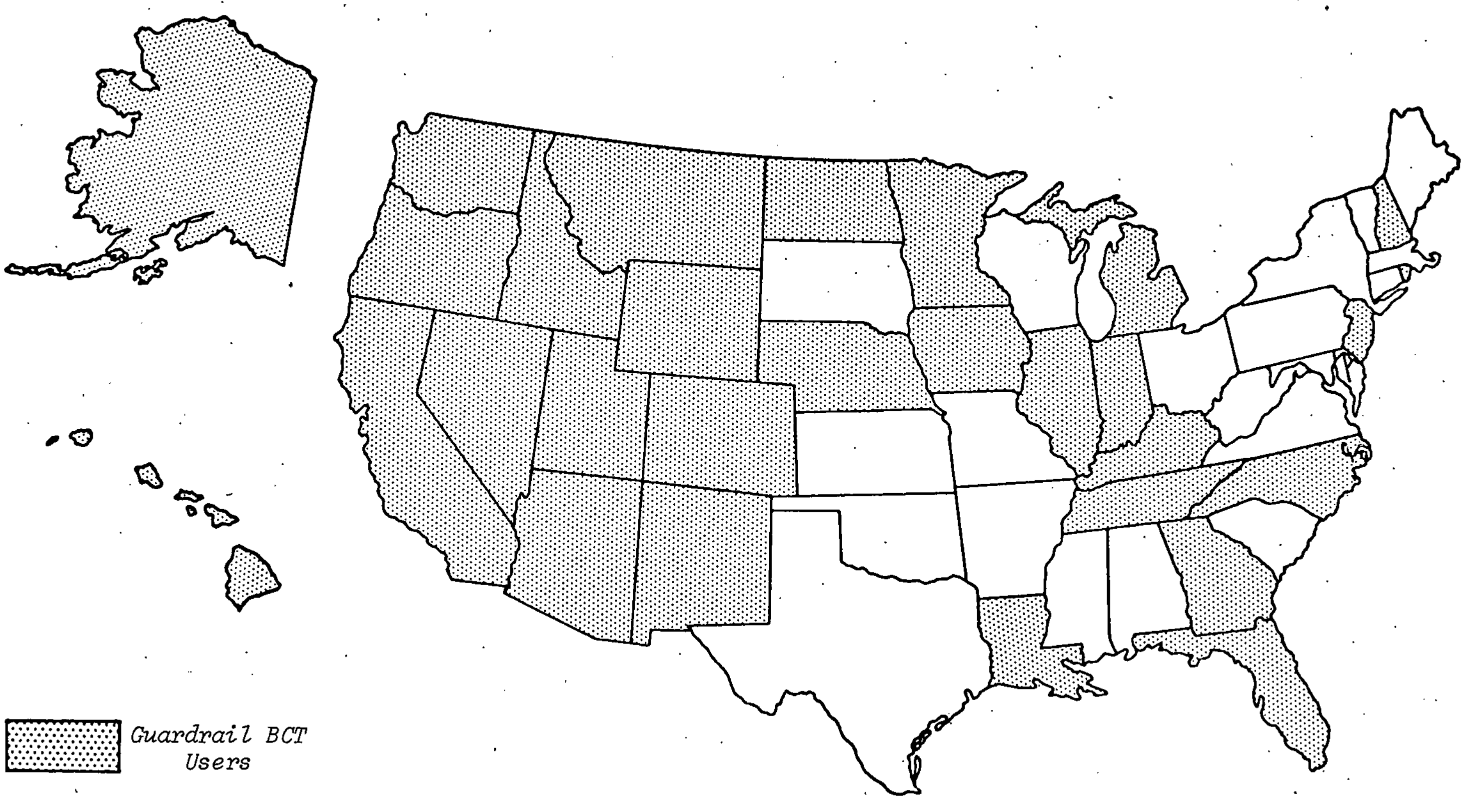


Figure 1. States using guardrail BCT. (Source: Syro Steel Co., Girard, Ohio)

around the post before casting the footing proved to be a workable solution to this problem. A special lag bolt/eye bolt welded assembly is threaded into the broken post top. The broken stub is then removed using a fork lift attached by chain to the bolt assembly. Replacement posts are trimmed as required to provide a snug fit in the footing socket.

A series of static tests conducted by Caltrans demonstrated that an 8- x 8- x 5/8-in. bearing plate was more than adequate for transferring the load from the anchor cable to the post. The distribution plates recommended for the 6- x 8-in. wood post BCT proved to be unnecessary. Tests also showed that the tapered washer used with the anchor cable assembly was not needed. The detail drawings in Figure 2 reflect the Caltrans changes.

Alternate Footings

The BCT devices rely on end posts that perform in a "breakaway" manner when impacted by a vehicle. Although the post foundation is important, there can be any number of adequate designs, depending on soil conditions.

Any foundation detail that provides the following is acceptable:

1. The breaking (breakaway) strength of the post must be developed by the foundation to ensure performance for end-on impacts (posts must break away and not lean in the soil).

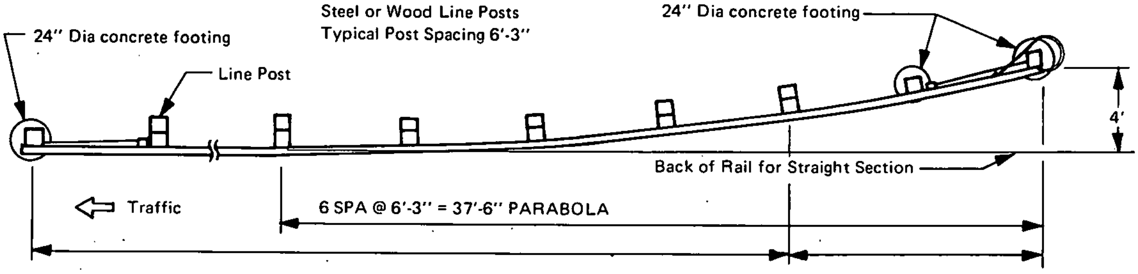
2. The loads transmitted by the anchor cable must be positively reacted by the foundation.

A foundation detail must meet these two criteria to be judged acceptable. States with unique soil problems should assure themselves that an adequate foundation is being specified.

The breakaway steel-post foundation system shown in Figure 3 utilizes a box beam and bearing plate and eliminates the need for a concrete footing. Recent pendulum tests at Southwest Research Institute demonstrated the adequacy of this design for both breakaway and anchorage performance in soil as characterized in NCHRP Report 153.[1]

Steel-Post BCT

Following publication of NCHRP Research Results Digest 84, the Federal Highway Administration sponsored four tests on the steel-post median barrier BCT.[2] These tests, which were conducted at Texas Transportation Institute, are summarized in Table 1. During the first test the under side of the vehicle (1971 Vega) snagged on the stub that remained after the foundation post broke away. Although the 4-in. height of the stub had not posed problems in previous tests, this occurrence was judged to warrant lowering of the foundation slip plate. Accordingly, SwRI designed a foundation post with minimal projection above grade to eliminate the snagging problem. Subsequent tests conducted by TTI demonstrated improved performance with this modification. Test results are summarized in Table 1. The guardrail and median barrier steel-post designs shown in Figures 4 and 5 include the recommended modification, which lowers the foundation post to minimize the risk of snagging the underside of a vehicle.



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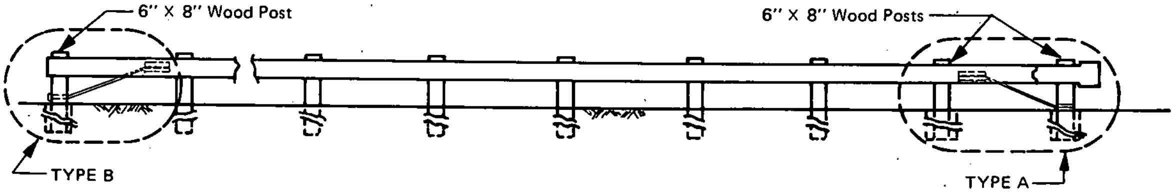
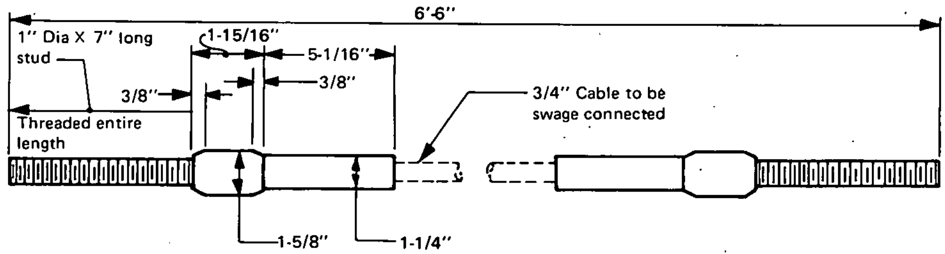
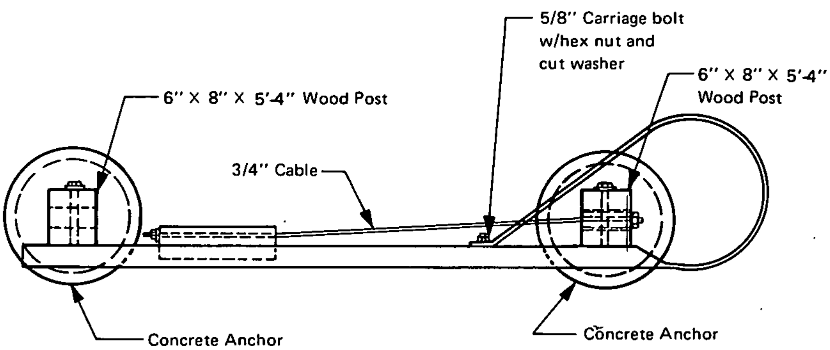


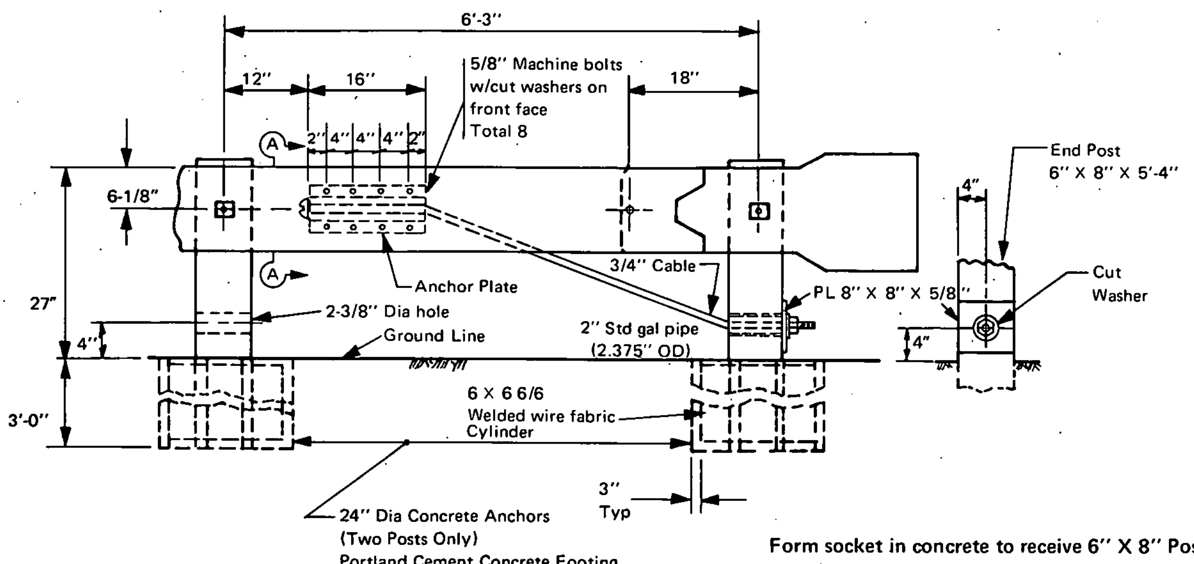
See Note 2

ELEVATION



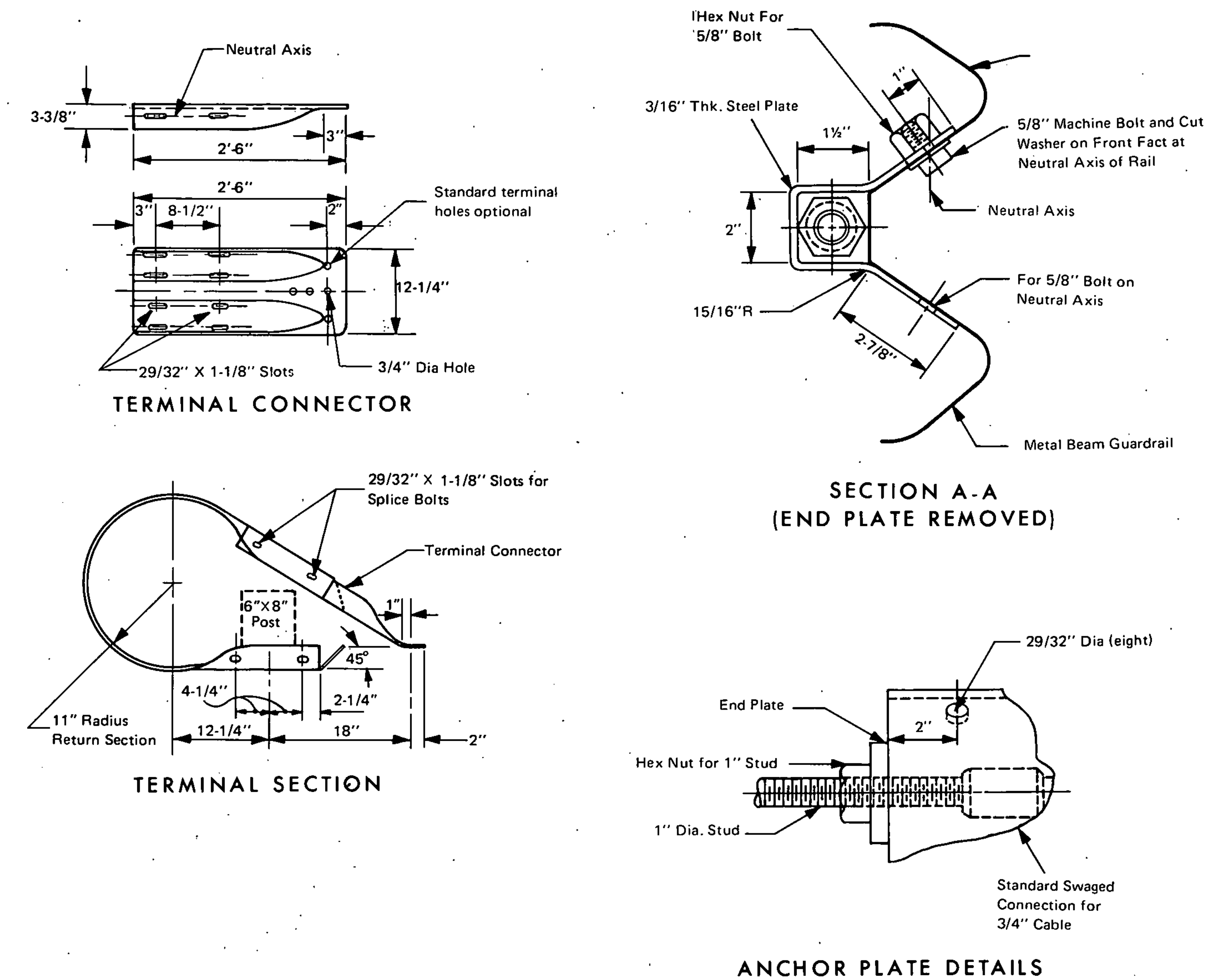
SWAGED FITTING AND STUD





Form socket in concrete to receive 6" X 8" Post or place concrete around 6" X 8" Post wrapped with material to facilitate broken post removal.

TYPE A TERMINAL



NOTES

1. This terminal is used with steel or wood post guardrail systems G4(1W), G4(2W), G4(1S) and G4(2S) as shown in AASHTO publication, "Guide for Selecting, Locating, and Designing Traffic Barriers," 1977.
2. For Trailing end of guardrail adjacent to one-way roadway omit Terminal Section. Next to last post to be a Line Post.
3. Posts to be centered in concrete footing.
4. Refer to latest edition of AASHTO-AGC-ARTBA publication, "A Guide to Standardized Highway Barrier Rail Hardware" for standardized parts.
5. Broken post removal can be achieved by screwing a special eye bolt/lag bolt into the post top. The post can then be removed with a lifting device attached to the eye bolt. Replacement posts may be trimmed to provide a snug fit in the footing socket.

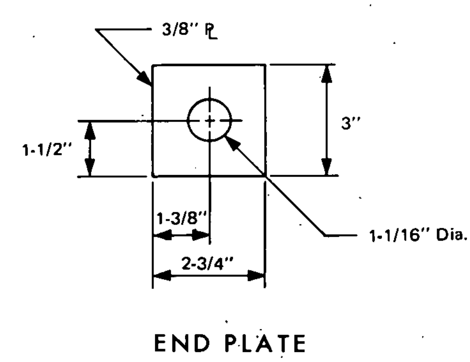
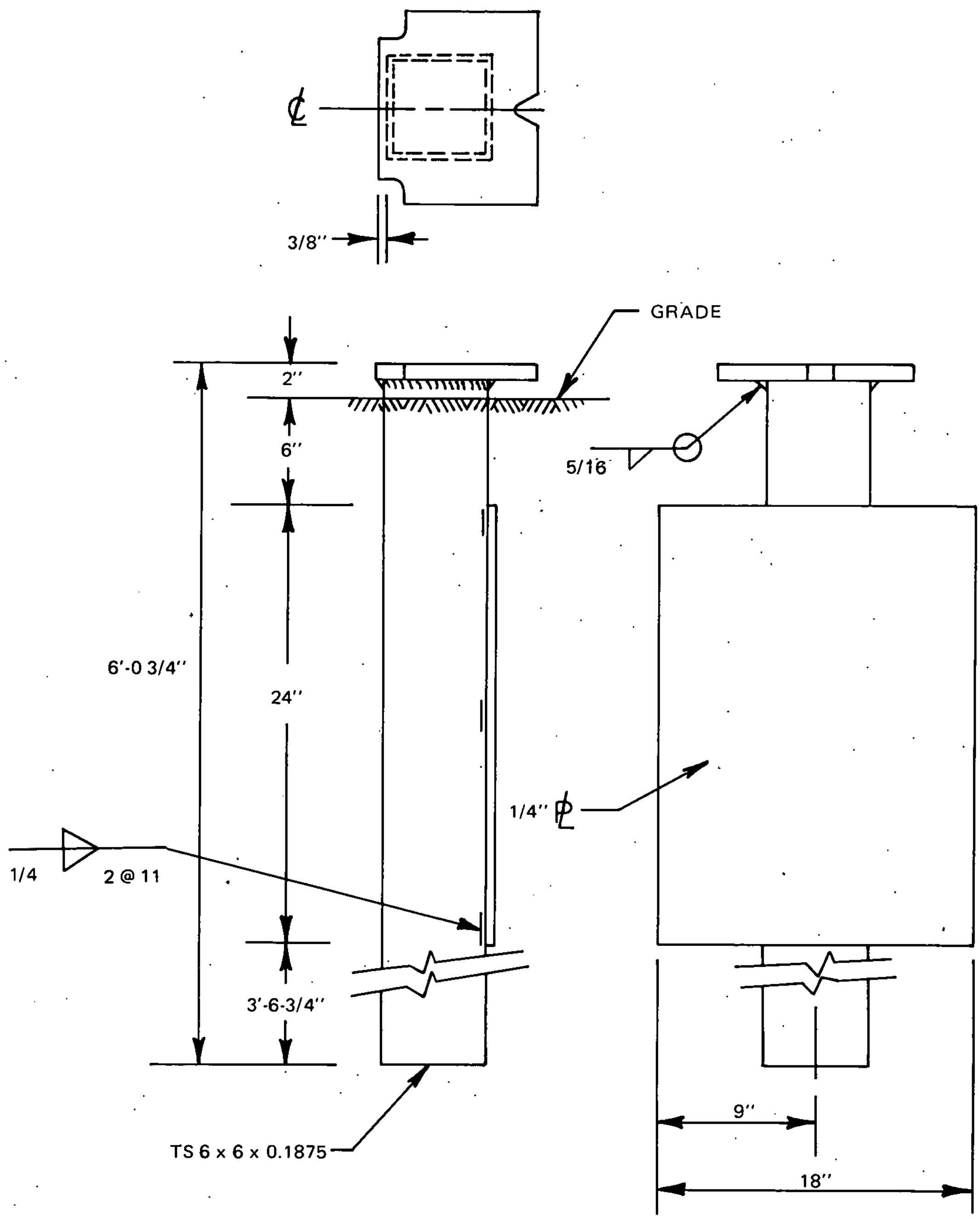


Figure 2. Revised wood-post BCT drawing.



Note: This detail is recommended for soil conditions as defined in <u>NCHRP Report 153</u>.

Figure 3. Modified steel-post BCT foundation designs.

<u>Flaring of Guardrail BCT</u>

The flare specified in the guardrail BCT system is considered essential to proper performance for end-on impacts that are nearly parallel to the straight section. The eccentric loading produced by the flare is needed to overcome the substantial resistance of the W-beam to axial loads from end-on impacts. The flare allows the vehicle to clear the portion of the installation that remains in place after the first two posts break away during an end-on impact.

Tests have demonstrated that the 4-ft offset flare performs successfully, and it is recommended as an essential feature of the guardrail BCT.

APPLICATIONS

Over-all, the BCTs for guardrail and median barriers are judged to meet service requirements and will perform satisfactorily for most vehicle impact conditions. Although results from several of the more demanding vehicle crash tests may be considered less than ideal, the BCT offers significant improvement over other existing designs.

The guardrail BCT designs as detailed in Figures 2 and 4 are recommended for immediate use. This relatively low-cost system (about $300) provides the designers with a terminal that has been evaluated over a wide range of impact conditions, using both timber and steel posts.

The four median barrier crash tests performed by Texas Transportation Institute demonstrated improved performance of the median barrier BCT with slip-base terminal posts, and the system detailed in Figure 5 is suggested for in-service trial use.

Users of the BCT should pay careful attention to details of the designs that may significantly influence performance of the terminal. The researchers warn that:

> Significant modification or deviation from proven details is discouraged, unless verified by full-scale testing. Retention of proven breakaway resistance values, anchorage capacity, W-beam and plate stiffness, etc., is essential to assure effective terminal performance and integrity.
>
> Breakaway terminal tests were performed on a relatively level surface; careful attention is suggested to assure this same condition for field applications in order to maintain proper terminal height relative to the vehicle's center of gravity. Accordingly, use of the terminals on raised islands or behind curbs is not recommended because of the potentially adverse effects of these elements on the terminal performance.

Those considering application of these terminals may wish to request loan copies of the agency's uncorrected draft final report from the NCHRP Program Director. Specific questions may also be directed to the Southwest Research Institute researchers through NCHRP.

The NCHRP Projects Engineer responsible for Project 22-2 is Dr. Robert J. Reilly, who can be reached at (202) 389-6741.

REFERENCES

1. Bronstad, M. E., and Michie, J. D., "Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances." NCHRP Report 153 (1974) 19 pp.
2. June 1977 Progress Report, FHWA Contract DOT-FH-11-8509. Texas Transportation Institute.

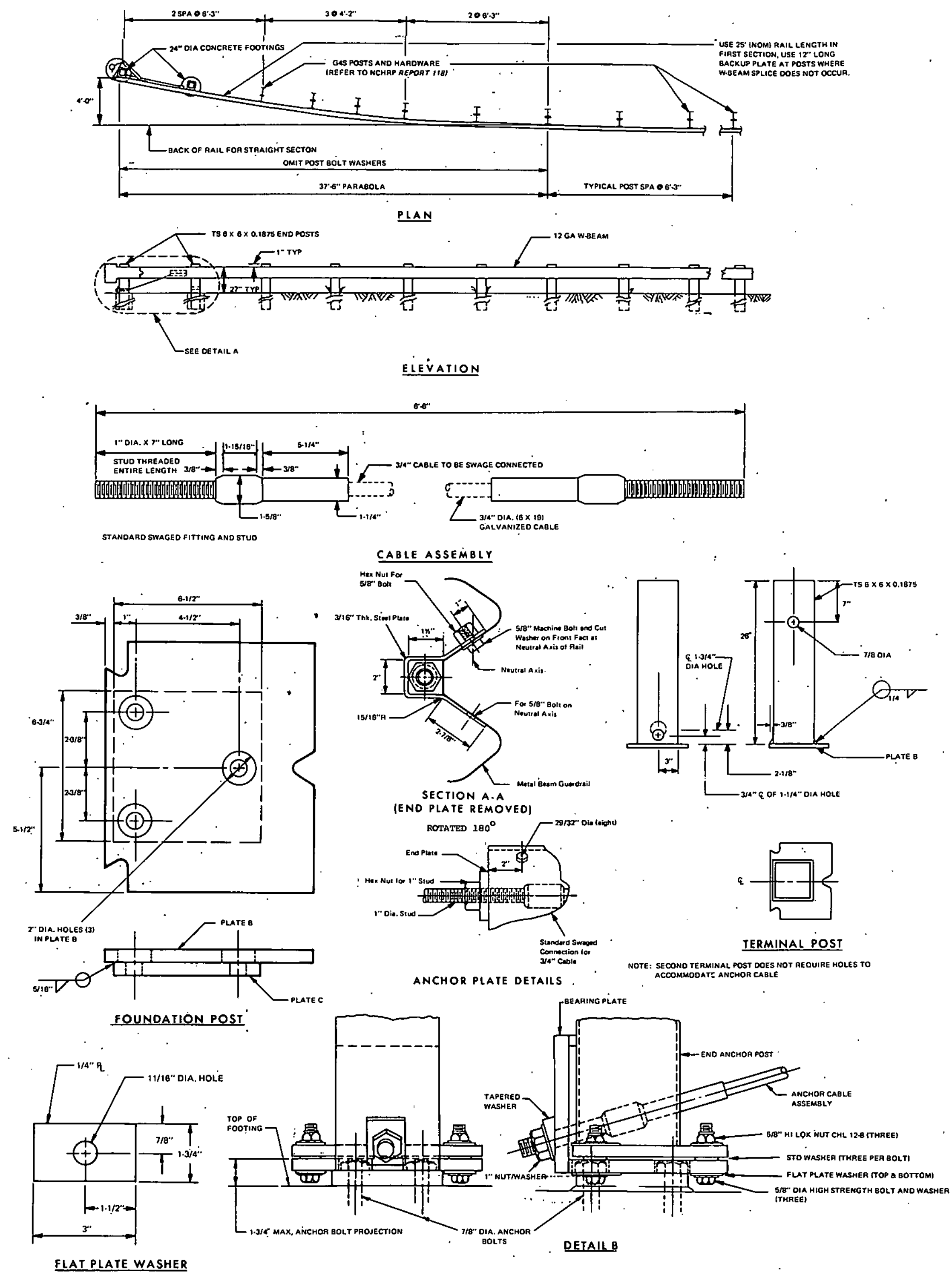
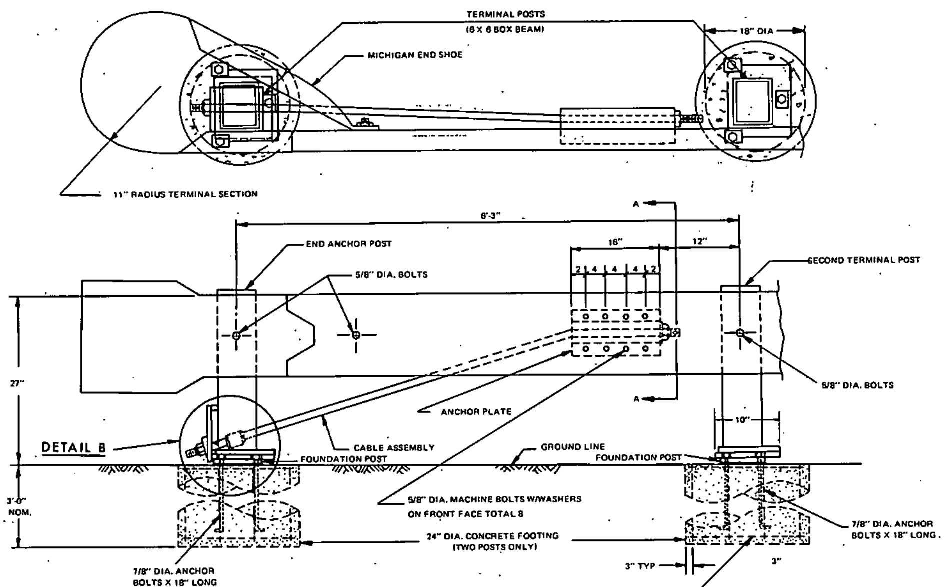
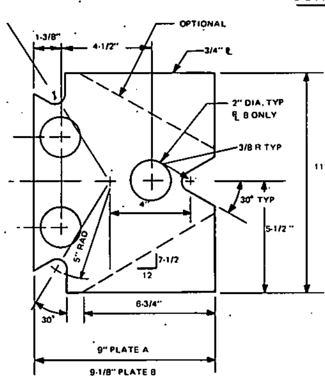


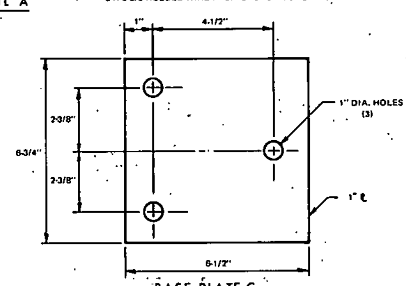
Figure 4. Revised steel-post BCT drawing.



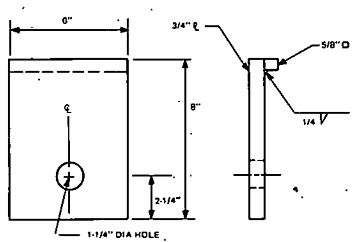
DETAIL A



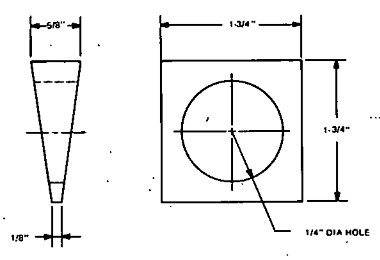
BASE PLATES A & B



BASE PLATE C



BEARING PLATE

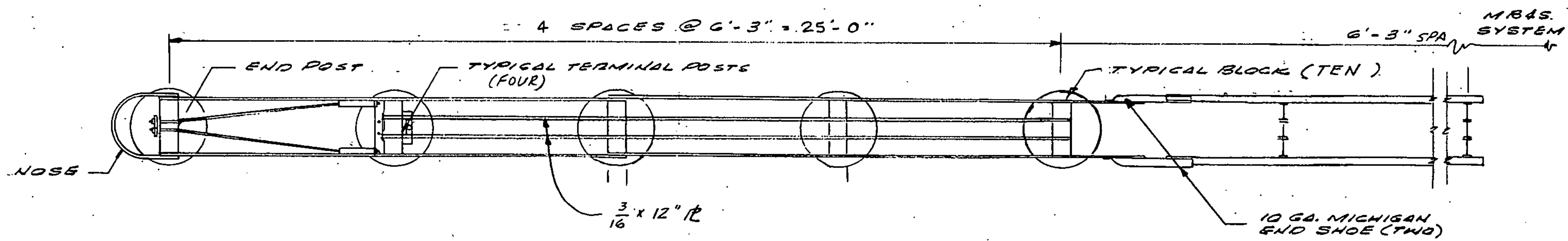


TAPERED WASHER

Notes:

1. Other anchor cable assemblies may be used. Minimum breaking strength of assembly should be 40,000 lbs.
2. Concrete footings are Class A (AASHTO). In sandy fill areas, conderation to increasing size of end footing is suggested.
3. Hi Lok nuts are product of Hi-Shear Corporation Torrance, California.

Slip base load may also be controlled with a calibrated torque wrench—Torque 155—170 ft-lbs



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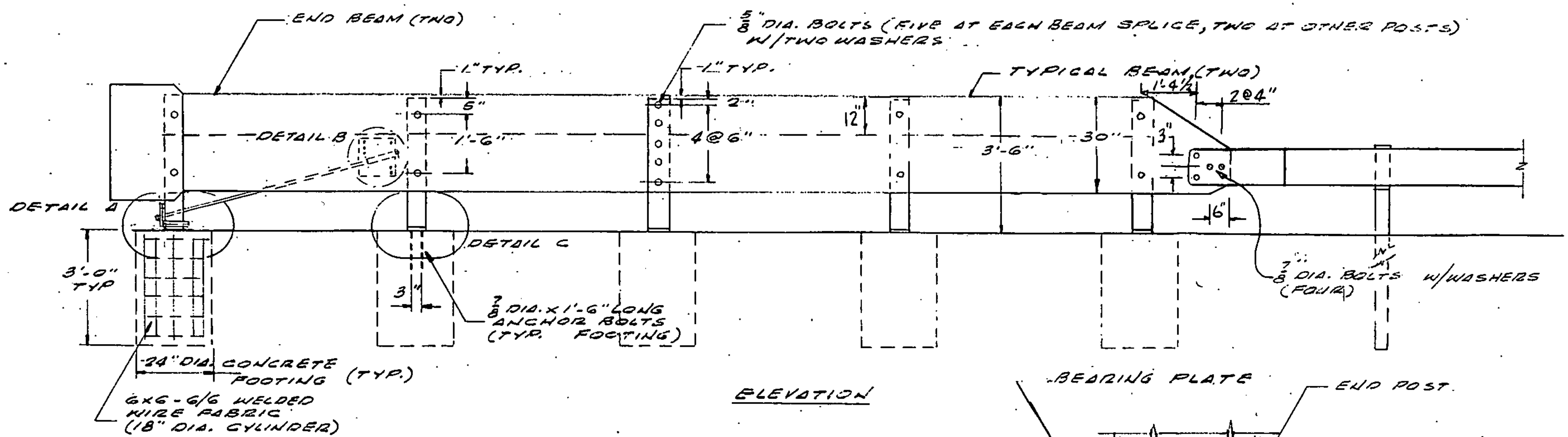
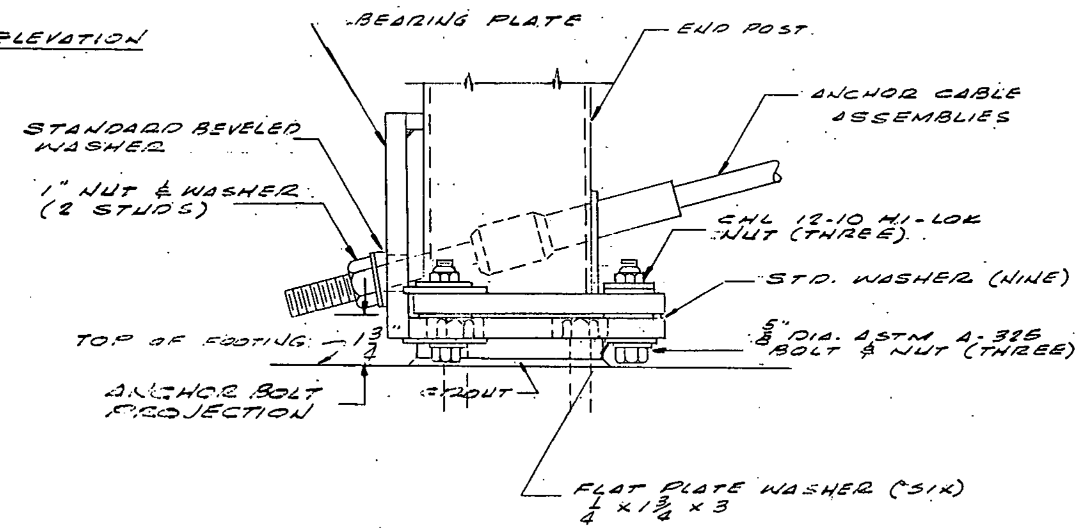


ELEVATION



DETAIL A

Notes:

1. The following specifications are applicable:

Box beam posts	-	ASTM A500 or ASTM A501
Sheet steel	-	ASTM 283, Grade D
Steel plate	-	ASTM A-36
Terminal bolts	-	Slip base ASTM A325; other, ASTM A307
Concrete	-	AASHTO Type A
Welded wire fabric	-	ASTM A-185

2. Torque on slip base bolts may be controlled by use of Hi-Lok CHL 12-10 nuts (product of Hi-Shear Corp., Torrance, Calif.) or bolt torque of 155-170 ft lbs.

3. The typical terminal post utilizes a breakaway weld at the base plate. The fillet weld should be 5/16" max., 1/4" minimum.

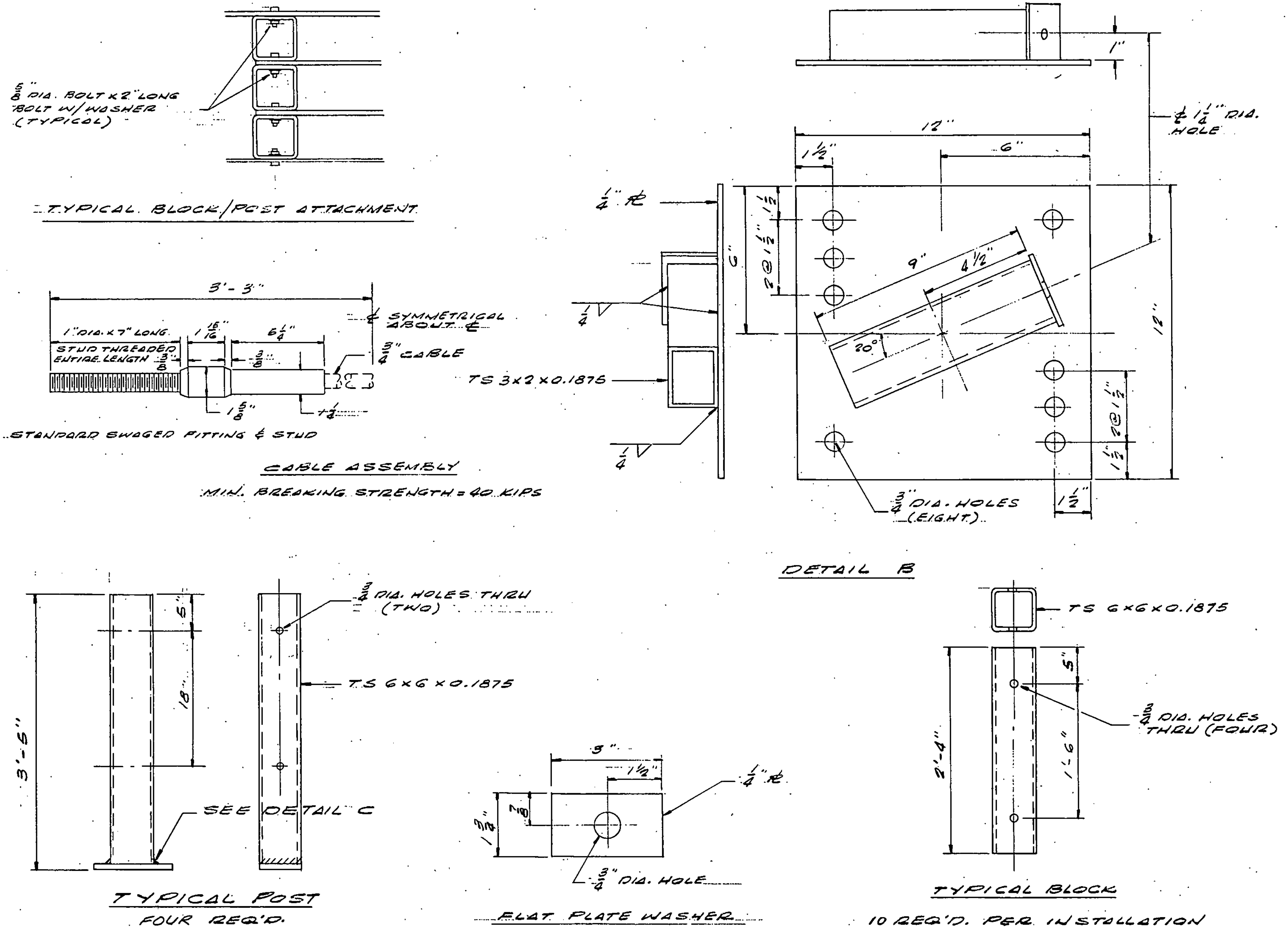


Figure 5. Revised median barrier BCT drawing.

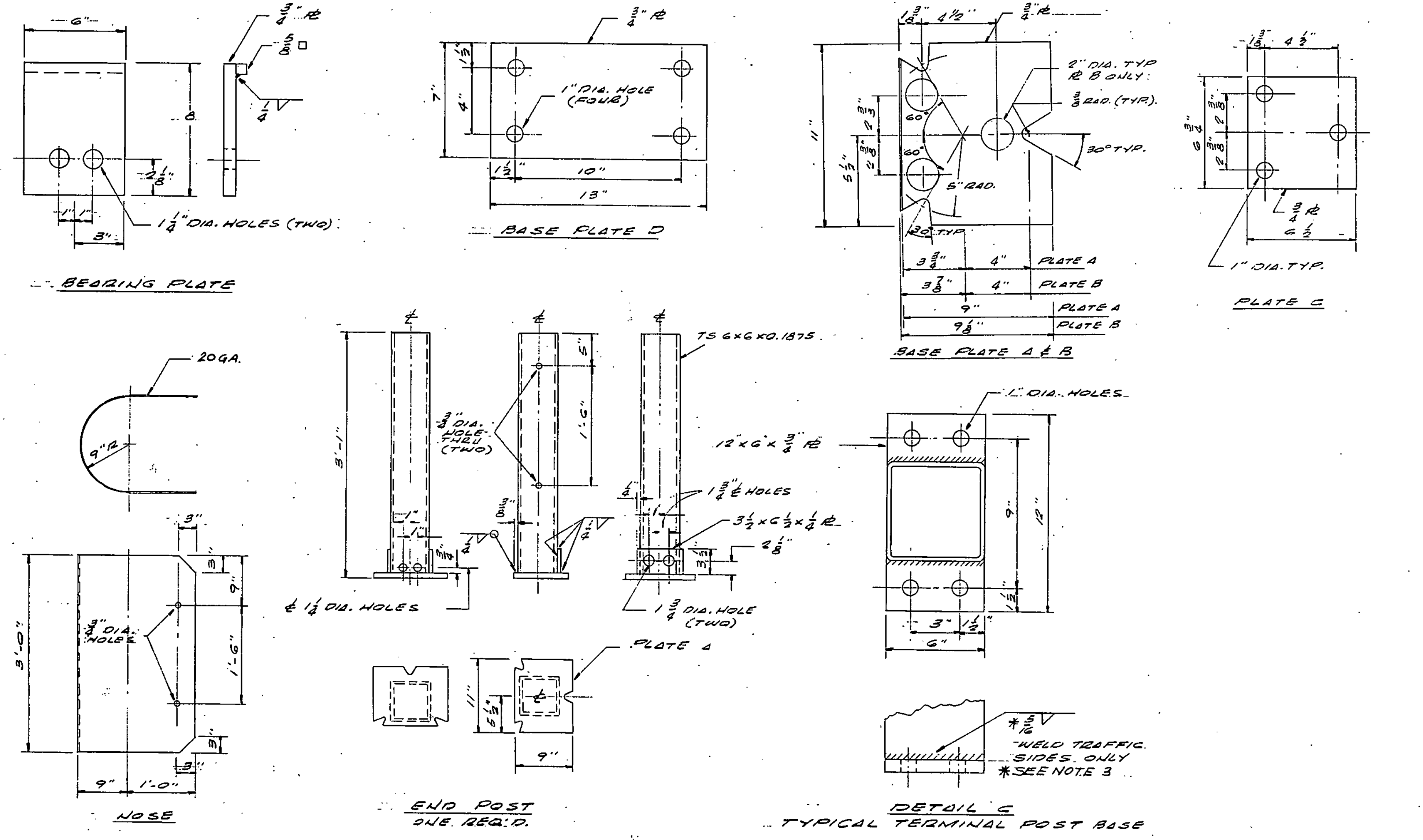


Figure 5 (continued).

TABLE 1

SUMMARY OF MEDIAN BARRIER BCT TESTS
AT TEXAS TRANSPORTATION INSTITUTE

TTI Test No.	Barrier* System	Vehicle Wt. (lb)	Vehicle Speed (mph)	Impact Angle (deg)	Max. Ave. Decel. in 50 msec (g) Long.	Max. Ave. Decel. in 50 msec (g) Lat.	Remarks
3	D, K	2330	65.9	0	22.9	5.1	Under side snagged on slip-base foundation; max. barrier penetration, 9.6 ft.
4	D, L	2370	59.1	0	16.7	7.4	Barrier featured lowered base; vehicle came to rest after 11 ft of barrier deflection.
5	D, L	4490	55.5	0	10.5	3.0	Full-sized vehicle used all of MBCT installation; maximum penetration more than 21 ft.
6	D, L	2270	31.0	0	11.5	—	Vehicle came to rest after 6.2 ft of barrier deflection.

*D = MB4S median barrier installed with MBCT.
K = MBCT steel post as shown in Research Results Digest 84.
L = Modified MBCT steel post as shown in Figure 5.

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