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DIVISION OF STRUCTURES AND ENGINEERING SERVICES

TRANSPORTATION LABORATORY

RESEARCH REPORT

EVALUATION OF FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POSTS

INTERIM REPORT

CA-TL-6317-77-26

SEPT. 1977

77-26

Caltrans

CALIFORNIA DEPARTMENT OF TRANSPORTATION

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TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. CA-TL-6317-77-26	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE EVALUATION OF FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POSTS		5. REPORT DATE September 1977
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) S. N. Bailey		8. PERFORMING ORGANIZATION REPORT NO. 19601-646317
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Transportation Laboratory California Department of Transportation Sacramento, California 95819		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS California Department of Transportation Sacramento, California 95807		13. TYPE OF REPORT & PERIOD COVERED Interim
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

Roadway delineation provided by guide markers and clearance markers supported by steel posts is lost after a vehicle impact which permanently bends the post to the ground. This study identifies several flexible plastic guide marker and clearance marker posts that can withstand several vehicular impacts without losing their effectiveness or causing damage to the offending vehicle.

The flexible posts evaluated in this study are divided into two groups, 1) Driveable, similar to a steel post, and 2) Non-driveable, which require provisions for a hole in the foundation and subsequent backfilling.

This report describes the vehicular impact testing and the in-progress durability testing utilizing a carbon arc fadeometer and controlled out door exposure.

17. KEY WORDS Plastic post, plastic delineators, flexible marker, traffic,safety.	18. DISTRIBUTION STATEMENT No restrictions, this document is available to the public through the National Technical Information Service, Springfield, VA 22161.

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	50	

DH-TL 1242 (Rev. 3-74)

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES & EGNINEERING SERVICES
OFFICE OF TRANSPORTATION LABORATORY

September 1977

TL No. 646317

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

EVALUATION OF FLEXIBLE PLASTIC GUIDE
MARKER AND CLEARANCE MARKER POSTS

Study made by . . . . . Structural Material Branch

Under the Supervision of . . . . . E. F. Nordlin, P.E.

Principal Investigator . . . . . J. R. Stoker, P.E.

Co-Principal Investigator . . . . . S. N. Bailey, P.E.

Report Prepared by . . . . . S. N. Bailey, P.E.

Very truly yours,

George A Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

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TABLE OF CONTENTS

		Page
I.	INTRODUCTION	1
II.	GUIDE MARKERS EVALUATED	2
III.	CONCLUSIONS	3
IV.	RECOMMENDATIONS	4
V.	TEST RESULTS AND DISCUSSION	6
	A. The Autopost Guide Marker Post	7
	B. Lanco T-Section Guide Marker Post	14
	C. Syroflex Guide Marker Post (Flexopost)	18
	D. Polypost Guide Marker Post	22
	E. Guardian Guide Marker Post	26
	F. Carsonite Guide Marker Post	30
VI.	APPENDIX	

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The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California. This report does not constitute a standard, specification, or regulation.

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I. INTRODUCTION

The Transportation Laboratory was requested by the Office of Traffic by letter of December 15, 1976, C. P. Sweet, Jr. to G. A. Hill, to continue the evaluation of flexible guide marker posts. This study would include 1) new products, their performance, and vehicular impact resistance; 2) long term durability tests; and 3) recommendations for improving the specifications for flexible guide and clearance markers. This is an interim report which describes the work done to date in evaluating the physical aspects of these flexible delineator posts. Vehicle impact tests were conducted on February 14 and April 29, 1977, at the Transportation Laboratory Dynamic Test Facility located within the confines of the Highway Patrol Academy at Bryte, California, a suburb of Sacramento. Further vehicle impact tests were conducted by one manufacturer on his product on May 25, 1977, in Carson City, Nevada. This test series was witnessed by Caltrans personnel. Also reported is an accelerated weathering correlation study currently in progress to estimate service life.

A maximum of ten 55 mph vehicular impacts were planned for each flexible guide marker post to be tested. The testing procedure conformed to Section D(5) of the attached "Specification for Flexible Plastic Guide Marker and Clearance Marker Posts" dated January 1977 and consisted of tests on groups of three identical guide markers posts installed per the manufacturer's recommendations. The performance of each post was evaluated by an observer who recorded any changes that occurred to each post as the result of each impact. The test performance of each type

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of post is described in detail within the body of this report and is further depicted by photographs that are included. Much of the vehicle impact testing was recorded on video tape on file at the Transportation Laboratory.

An accelerated weathering test is currently being conducted on samples of the plastic material from each marker post utilizing the Carbon-arc Fadeometer. These test results will be correlated to the results of normal outdoor weathering on other samples currently being exposed on the roof of the Structural Materials Laboratory. From this series of tests an estimate will be made for the service life of each guide marker post and ultimately, after this correlation information has been firmly established, an accelerated weathering test will be recommended as a future specification requirement.

II. GUIDE MARKERS EVALUATED

Guide marker posts tested by the Transportation Laboratory for vehicular impact resistance were manufactured under the following trade names: 1) Autopost, 2) Lanco, 3) Syroflex, 4) Polypost, 5) Guardian, and 6) Carsonite. The groups of guide markers posts can be divided into two broad categories, namely; (1) a driveable guide marker and (2) a non-driveable guide marker. Installation of a non-driveable marker requires a hole to be made in the ground and backfilled.

The Carsonite guide marker post is the only one in the tested group which is considered to be a driveable type. It can be driven into the ground like a metal guide marker post. The manufacturer of the Guardian guide marker post claimed his marker was semi-driveable; however, no practical method was found during the study to drive the post.

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The non-driveable guide marker posts can further be divided into two groups, one group requiring and one not requiring backfilling in the interior of the post as well as around the outside. The Autopost, the Guardian, the Lanco are the non-driveable type posts which do not require interior backfilling. The Syroflex and the Polypost both require interior backfilling as well as backfilling around the outside of the post up to the ground line.

III. CONCLUSIONS

When tested in relatively mild temperatures between 70 and 80°F, it was found that all but one of the non-driveable guide marker posts tested were able to withstand the currently specified 10 vehicular impacts at speeds of 55 mph and return to a vertical position. The Carsonite driveable guide marker post was found to perform satisfactorily at vehicular impact speeds up to 35 mph. This marker post failed at an initial impact speed greater than 35 mph, and even at speeds up to 35 mph the damage to the top of the post became objectionable when the number of impacts was between 5 and 10.

Based on these series of tests and observations, it is concluded that the following posts are acceptable with respect to vehicular impact resistance: 1) Autopost, which includes triangular with rounded corners, rounded, and cloverleaf shaped cross sections; 2) Syroflex, and 3) Polypost.

The Carsonite ribbed post is acceptable with respect to vehicular impact at 35 mph and 5 impacts but not 10 impacts. After the formation of a plastic hinge in the post at the supporting surface from the lower speed impact, the post is able to withstand repeated impacts at speeds up to 55 mph.

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The Lanco T-section guide marker post is not considered satisfactory, even though it tended to return to a vertical position. After a few vehicular impacts this post developed an objectionable "S" shaped curve which probably would not be considered acceptable.

The Guardian guide marker post is not considered acceptable from vehicular impact. This post is constructed with two sections that are riveted together. These sections separated after the first impact. The front section of the guide marker shattered on recurring vehicular impacts. It appears that considerable modification in the design and construction of the Guardian post would be required to improve its performance.

The amount of work required to install the various guide marker posts varied considerably due to their design. This variation would be a factor in a cost effectiveness comparison between the different posts. The driveable Carsonite post requires considerable less effort to install than the non-driveable posts. Also, it should be expected that the non-driveable posts which do not require interior backfill would be less expensive to install than posts that do.

IV. RECOMMENDATIONS

1. It is recommended that the program to evaluate the long time service durability under various environmental conditions found in California be continued. This program would include the laboratory weatherability study which is underway and a systematic monitoring of field installed guide markers.

2. Determine the installation time for the various guide-markers by which the total cost effectiveness could be evaluated.

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3. It is suggested that a separate specification be prepared for the driveable guide marker post to allow its use in areas of low impact susceptibility or for conditions where its assets offset its disadvantages. Attached is a suggested specification that could be used for ordering driveable guard marker posts.

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V. TEST RESULTS AND DISCUSSION

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A. The Autopost Guide Marker Post

The triangular cross section Autopost guide marker post had been tested previously and found to be satisfactory for vehicular impact resistance. Two new Autopost designs, consisting of a circular cross section and a cloverleaf cross section were evaluated in the vehicular impact tests of February 14, and April 29, 1977. The circular post has a diameter of 3 1/2" and the cloverleaf post has a relatively flat face of 4" which is oriented toward the oncoming traffic. See Figure 1 for details of the Autopost. Photographs of the cloverleaf post are shown in Figure 2 and the circular post in Figure 3 and 4. These guide marker posts are made of a light, flexible plastic with the bottom ends flared approximately 1" to serve as part of the anchoring system. These are non-driveable posts which require a drilled hole with subsequent backfilling to install the post. This post is constructed with a foam plastic plug in the bottom buried length (up to the ground line) which eliminates the need for backfilling inside the post. A short length of foam plastic is also placed inside of the top of the hollow post to serve as a seal to prevent water or other materials from entering.

These two guide marker posts (circular and cloverleaf cross section) both performed very adequately when subjected to ten vehicular impacts. They automatically returned to the vertical position after each vehicular encounter.

The foam plastic plug placed in the top of these guide marker posts dislodged and was knocked out on the first vehicular impact. However, the guide markers performed very adequately without the top foam plug for the remaining impacts.

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Both shapes of these guide marker posts were pulled out of the ground 1 to 3 inches after the 10 vehicular impacts. It is considered, however, that the anchoring system is adequate in restricting the pullout to the degree observed. The photos in Figures 1 and 2 show the amount of pullout as the distance the black line has been raised above the ground level.

The amount of vehicular damage when striking these guide markers at 55 mph is considered very minimal. No apparent damage was detected on the vehicle from any of these encounters. The damage to the three posts tested in each shape was also considered minimal.

The photo in the upper left corner of each figure shows one post before the first impact and the other three photos on the page show all three posts after 10 vehicular impacts. The reflective sheeting (Reflexite) on the post is damaged from the vehicular impacts and allowances must be made for replacement after a few impacts, even though in some cases the reflective sheeting lasted for the entire ten vehicular impacts.

Many Autoposts have been installed throughout California and their long term weatherability and serviceability will be apparent with the passage of time. In addition to the evaluation from actual field use, samples of the Autopost have been placed on the roof of the Structural Materials Laboratory for weathering and samples are being exposed in the Carbon Arc Fadeometer to determine their durability and resistance to change from ultraviolet light.

Further laboratory testing will measure the loss or change in tensile strength and elongation attributable to weathering and ultraviolet light exposure as well as visual change.

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It is recommended that the Autopost be considered acceptable on an interim basis. They are capable of complying to the requirements of the present specification for non-drivable flexible plastic guide markers. Even though our test series showed that the circular section guide marker would perform adequately with the omission of the bottom foam plug or other interior backfill, the manufacturer has not recommended installation without the backfill or foam. Therefore, this change is not recommended at this time.

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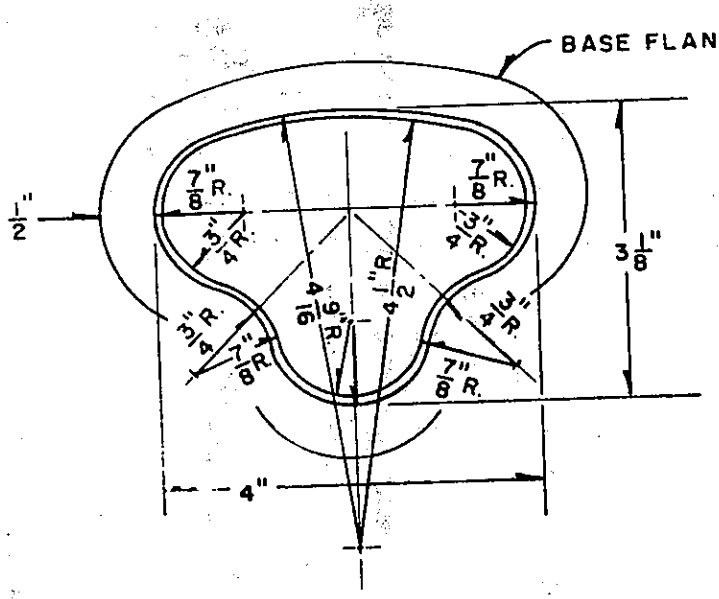
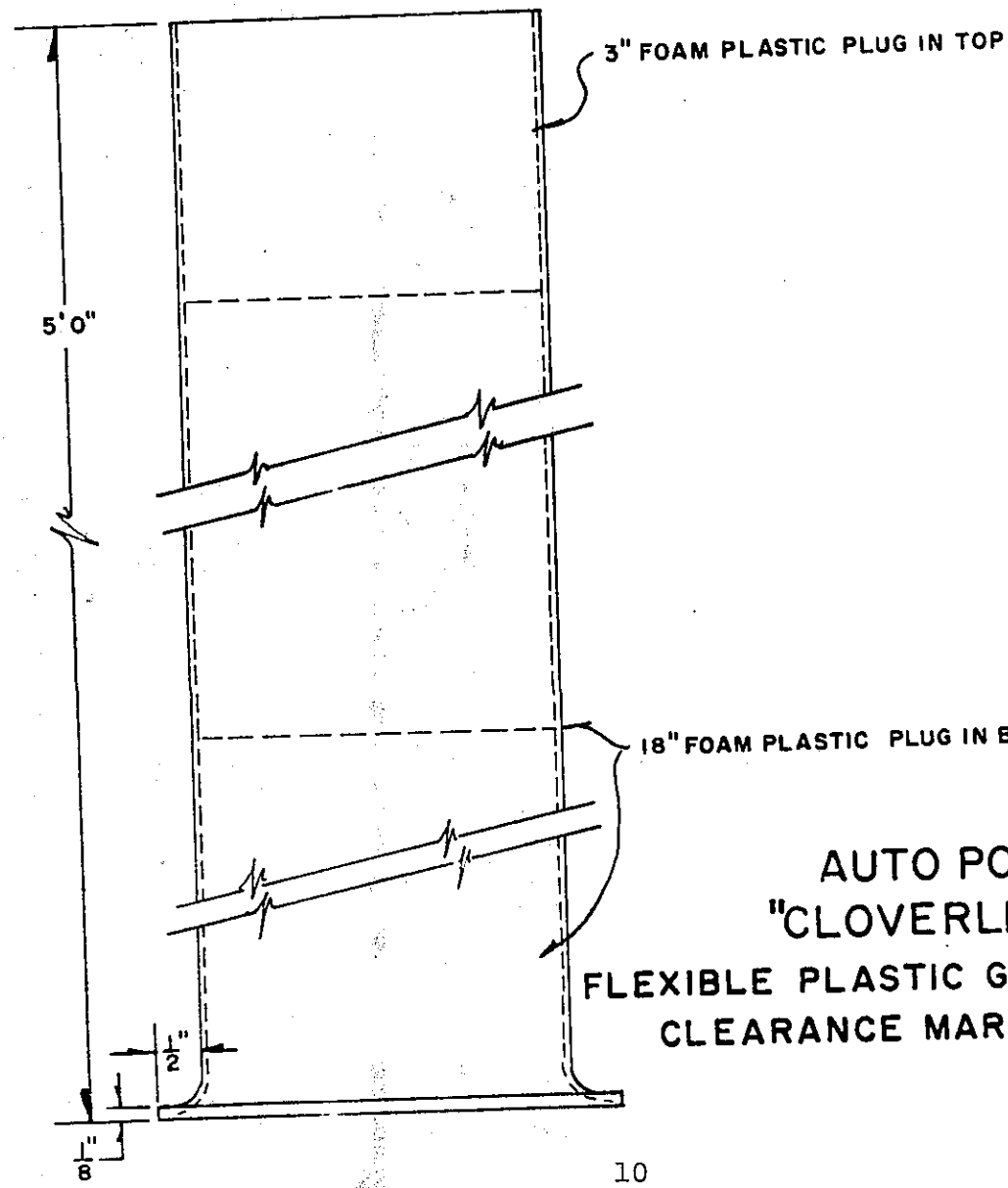
Figure 1





AUTO POST
"CLOVERLEAF"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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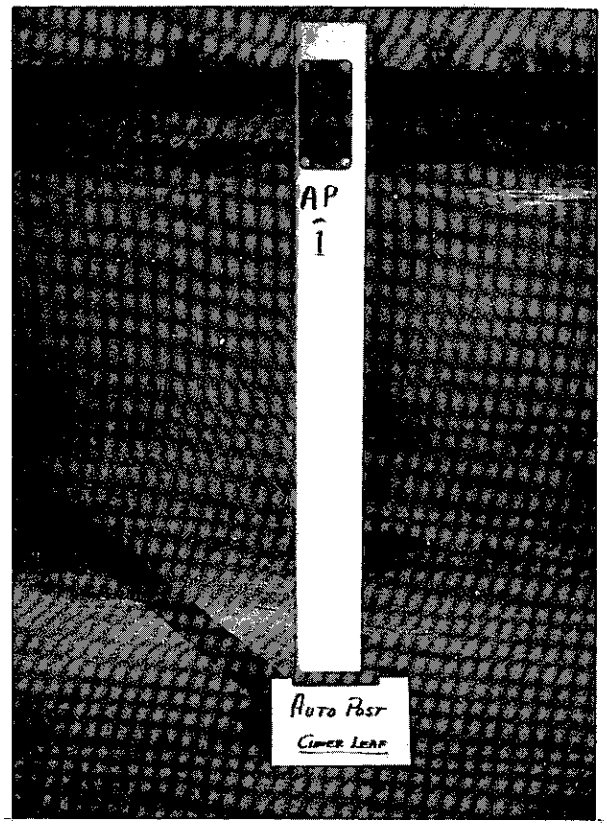
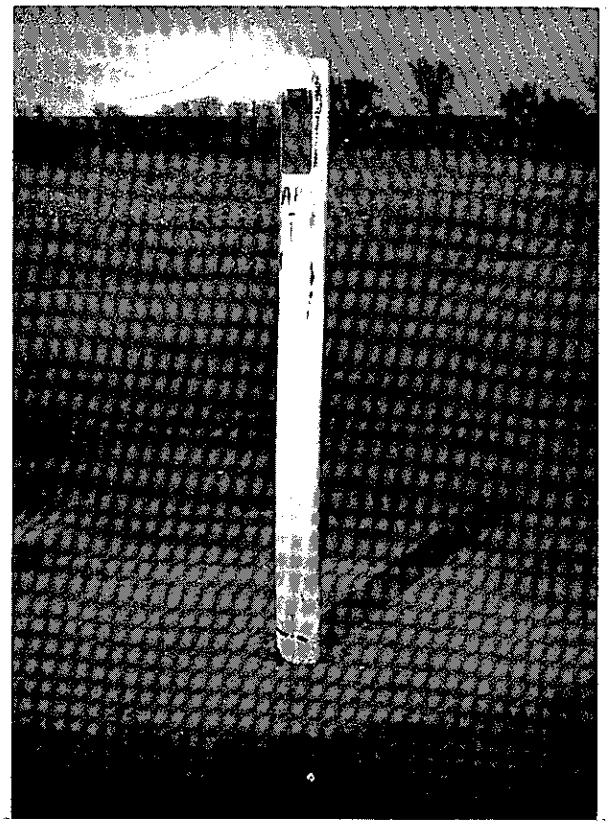
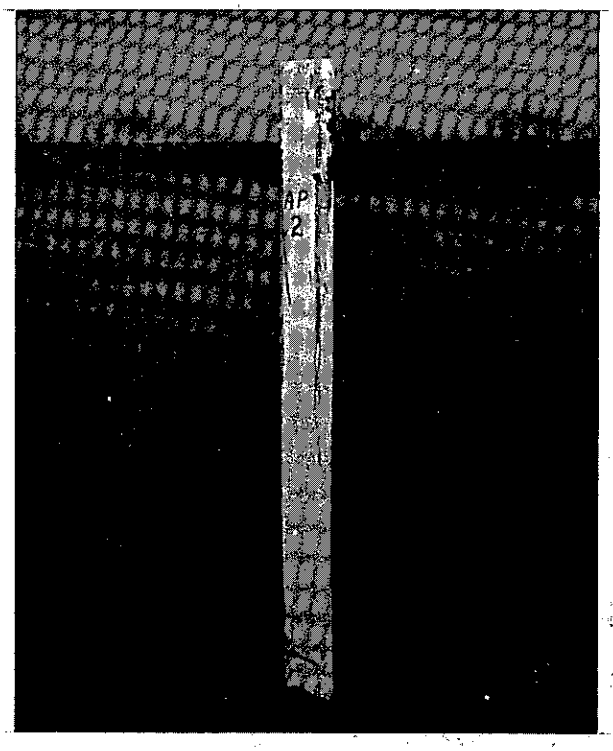
AUTOPOST - CLOVERLEAF POST Figure 2







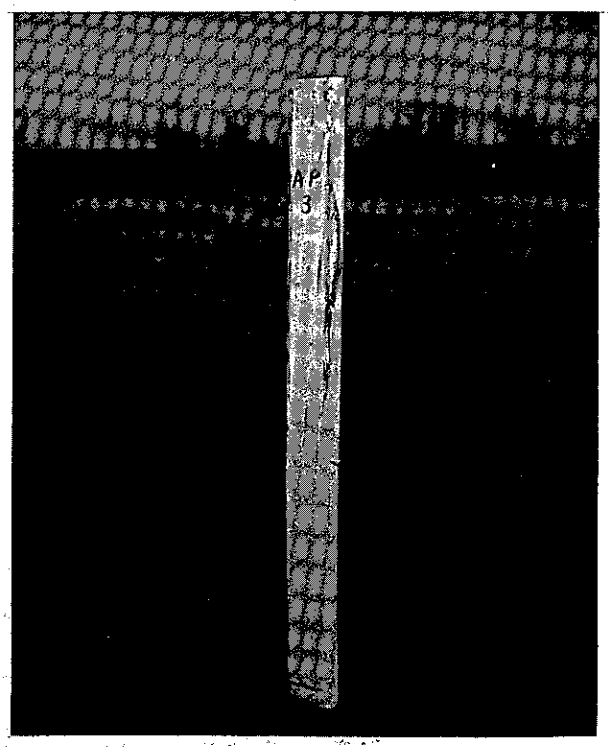


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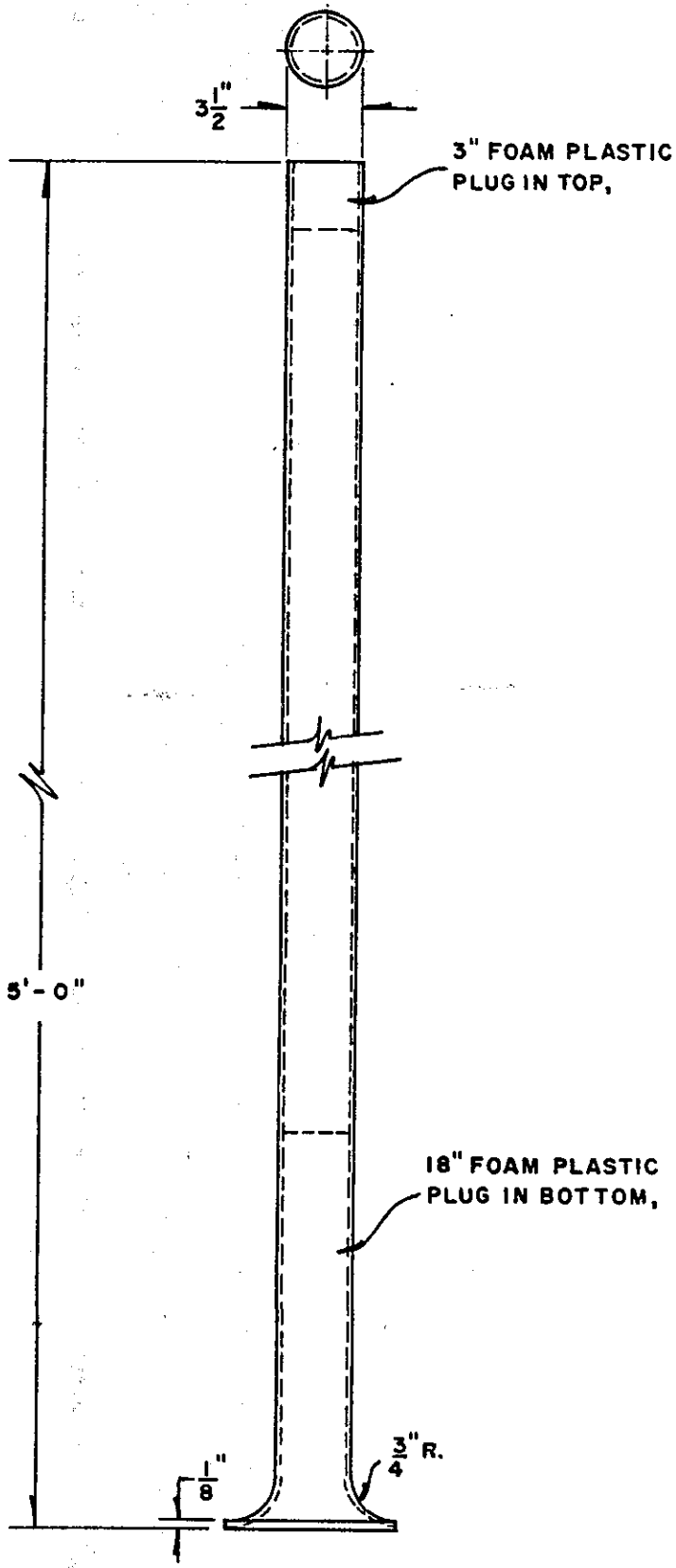
Figure 3



AUTOPOST,
CIRCULAR

FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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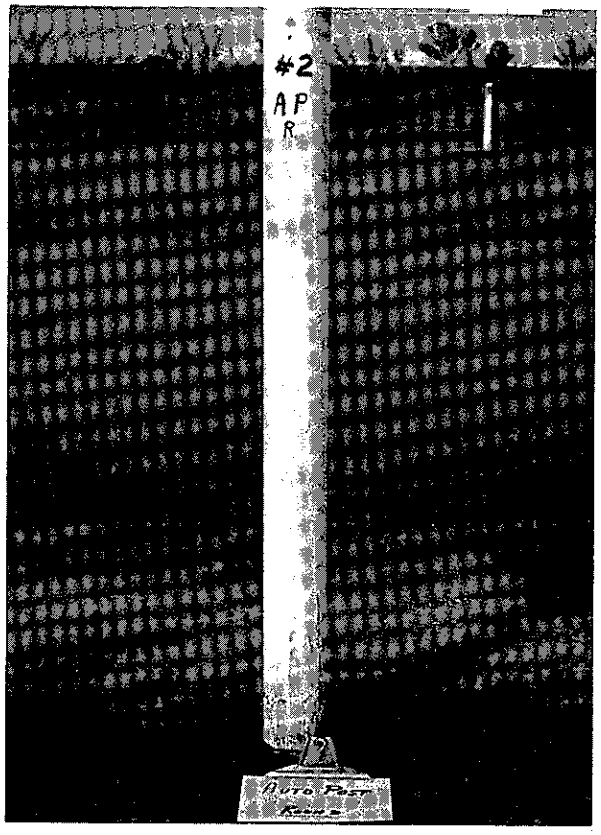

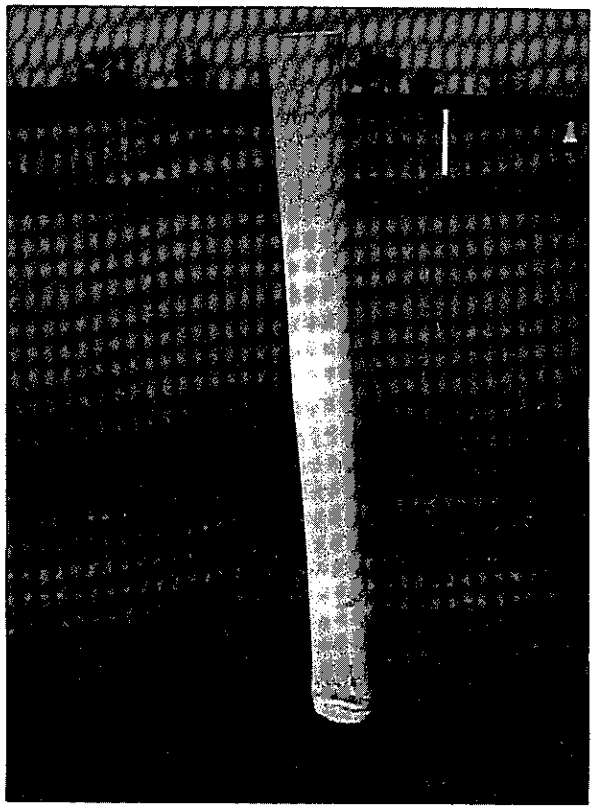

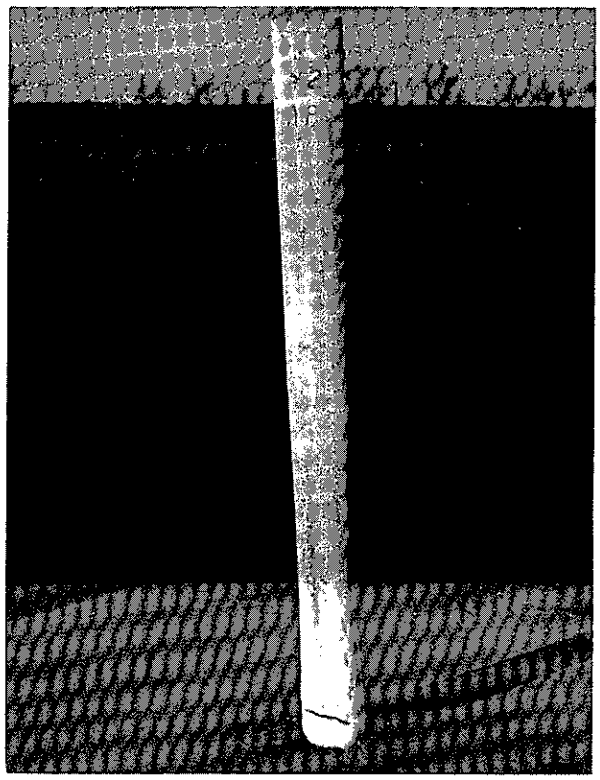

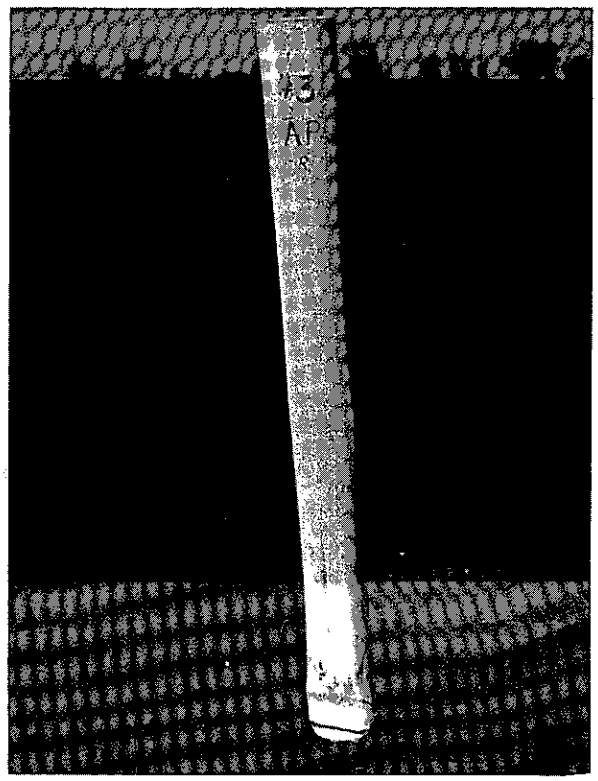

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B. Lanco T-Section Guide Marker Post

Lanco had previously submitted and Caltrans had tested and approved a flexible guide marker post designated as their LPD-6 post. However, this post differs greatly from the new T-secion guide marker post we tested on February 14, 1977. This new Lanco T-section marker post was tested with 10 vehicular impacts. This test was conducted on Sample No. SM76-1376 which was a special run of materials by the manufacturer. On April 29, 1977 another series of vehicular impacts was conducted on another sample of T-section guide marker submitted by the manufacturer which he stated was a production run. The latter sample was assigned laboratory number SM77-0188. Both samples appeared very similar as well as their test performances.

This guide marker post is made of a flexible white plastic with a 3" face and a 1 1/2" T web. The thickness of the face and the web is approximately 1/8". This guide marker is a non-driveable type which does not require interior backfilling. See Figure 5 for details of the Lanco T-post. Photos in Figure 6 show the appearance of the guide marker before and after impact.

There was little or no damage to the vehicle from any of the 55 mph impact tests. The guide marker post tended to return to an approximate vertical position after each impact with a pullout of 0 to 1/2" from the ground. After the first vehicular impact the marker canted 5 to 20° from the vertical. After 10 impacts the post approached a canted position of 30° from the vertical. During the vehicular impacts the post developed an S-shaped curve as can be seen in one of the photos. It is considered that this shape and appearance would not be acceptable even though the marker returned to a semi-upright position. Due to this deformed shape, this marker is not considered acceptable.

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It is recommended that no further testing be performed with this specific Lanco T-post design as a flexible guide marker post. Its performance does not compare with the other flexible guide marker posts being evaluated.

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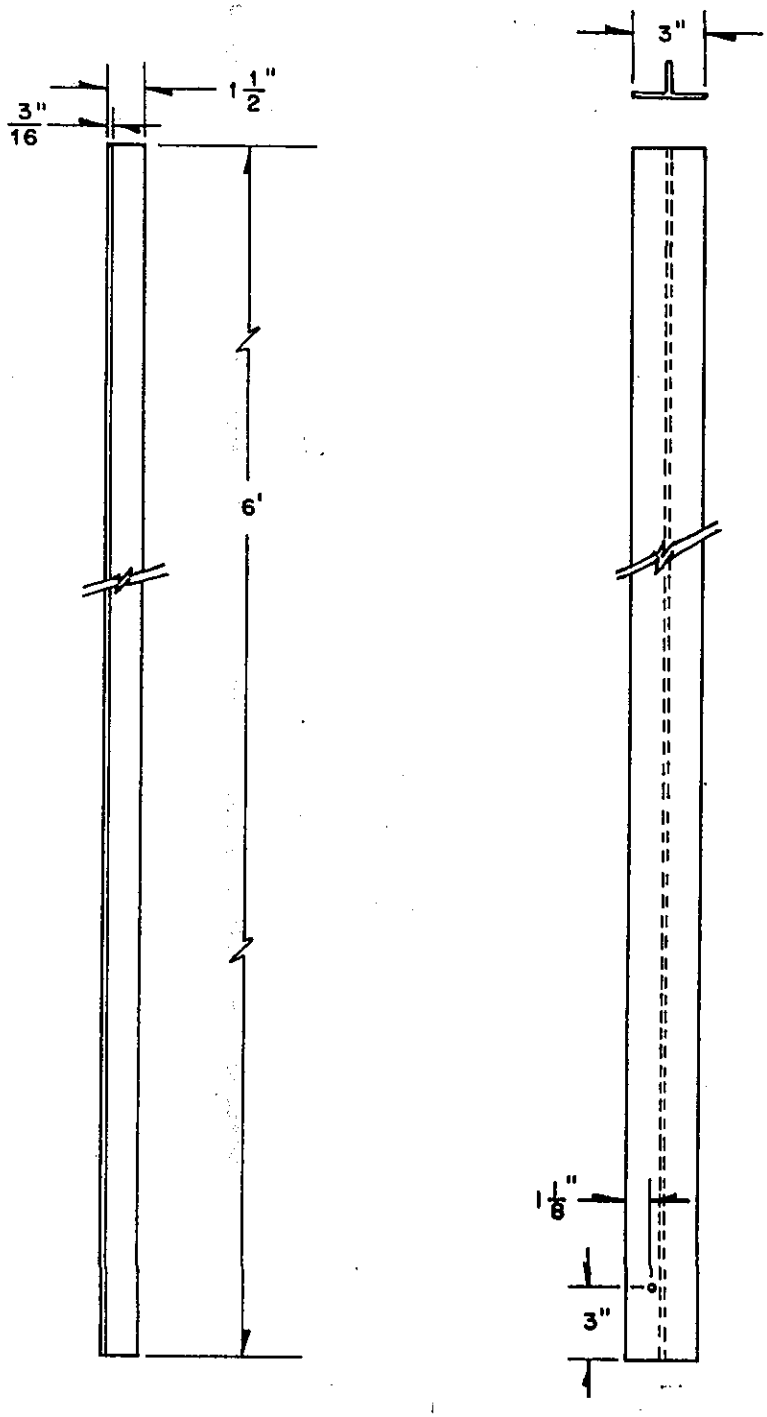

LANCO "TEE"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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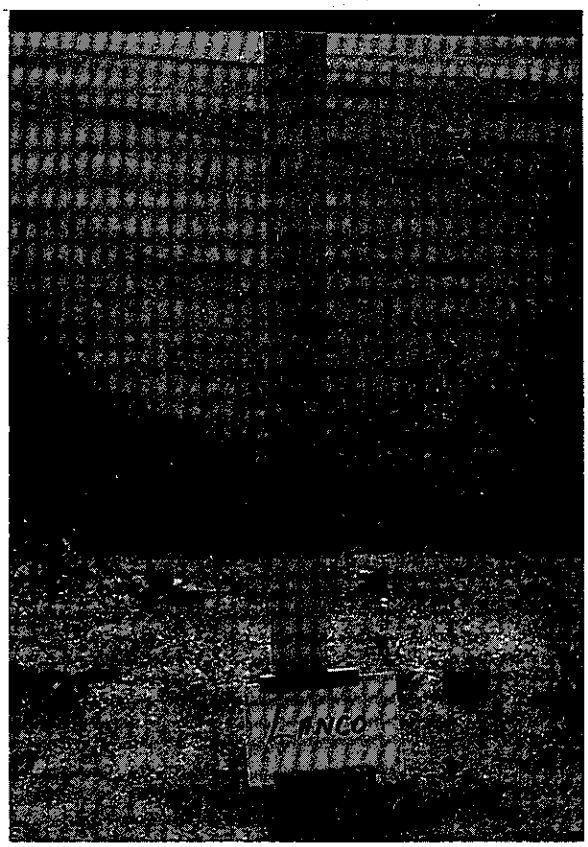

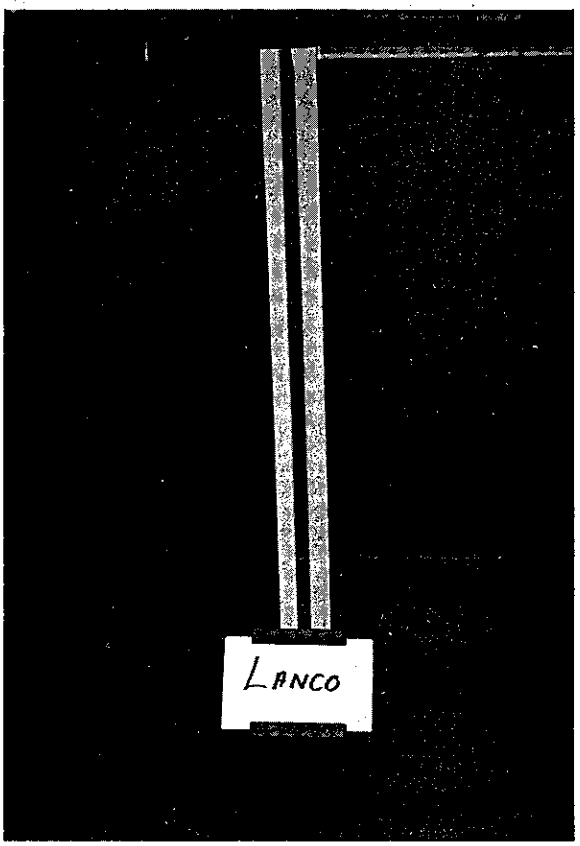

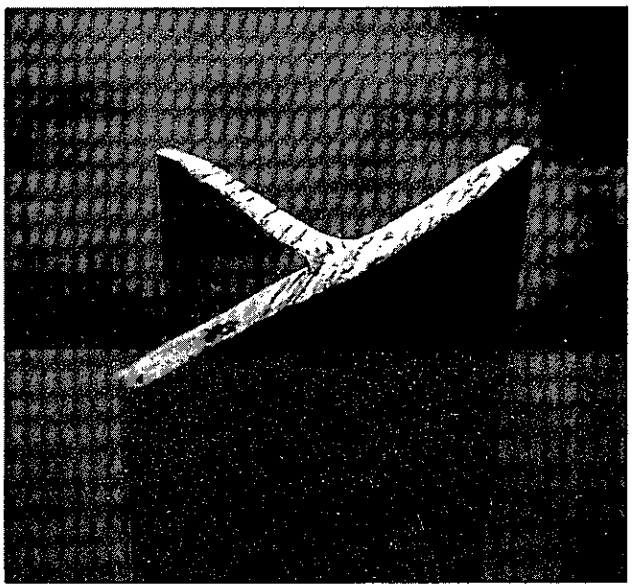

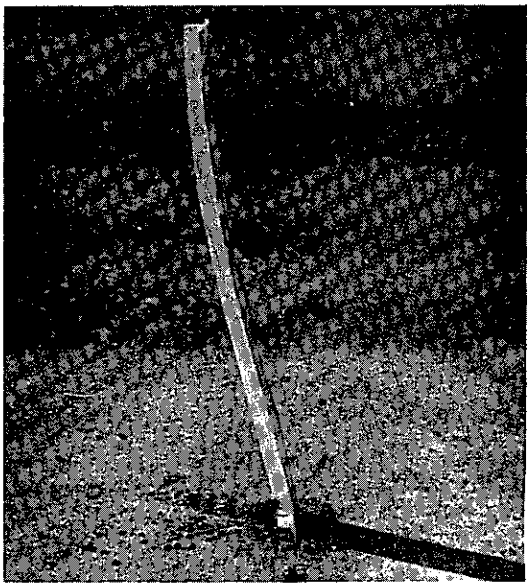

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C. Syroflex Guide Marker Post (Flexopost)

On February 14, 1977, the Syroflex guide marker post was tested with 10 vehicular impacts. This guide marker post had previously been tested and approved by Caltrans and there are many installations throughout the state. It is fabricated from a flexible white plastic and has an isosceles triangle cross section. The long sides of the isosceles triangle are approximately 4 3/4" and the short sides approximately 4" wide. The side facing the traffic consists of one of the long legs of the triangle. See Figure 7 for details of the Syroflex post. This guide marker post is a non-driveable type; a hole has to be provided in the ground to install the guide marker, the interior of the marker requires backfilling. A black cap is provided by the manufacturer to cover the top and keep water and debris out of the interior of the post. This post is shown in the photos in Figure 8.

This guide marker post was able to withstand the 10 vehicular impacts at 55 mph and satisfactorily return to a vertical position, as was found in earlier tests and evaluations. The black cap cover on the top of the post was knocked off on the first vehicular impact. The upper left photo in Figure 8 shows one of the three posts tested before the first vehicular impact and the other three photos show all three posts after the 10 impacts. The damage to the vehicle from the impact was minimal. The damage to the posts was also considered minimal. The anchoring system for this guide marker was satisfactory with only 1/2" to 1" pullout from the ground after the 10 vehicular impacts.

Presently we are attempting to estimate the long term weatherability and serviceability of this post from the many field

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Installations which have been made over the past years. We have a number of examples of extreme change in the plastic from outdoor weathering and sunlight exposure where the plastic loses its flexibility, becomes brittle and discolored. The weathered marker then fractures under vehicular impact. The evidence indicates that long term serviceability of this marker is not acceptable. Presently we have outdoor exposure samples on the Transportation Laboratory roof and laboratory fadeometer tests underway to better estimate its durability.

It is recommended that further installations of this marker post be forestalled until suitable evidence is developed or obtained which would attest to its long term serviceability.

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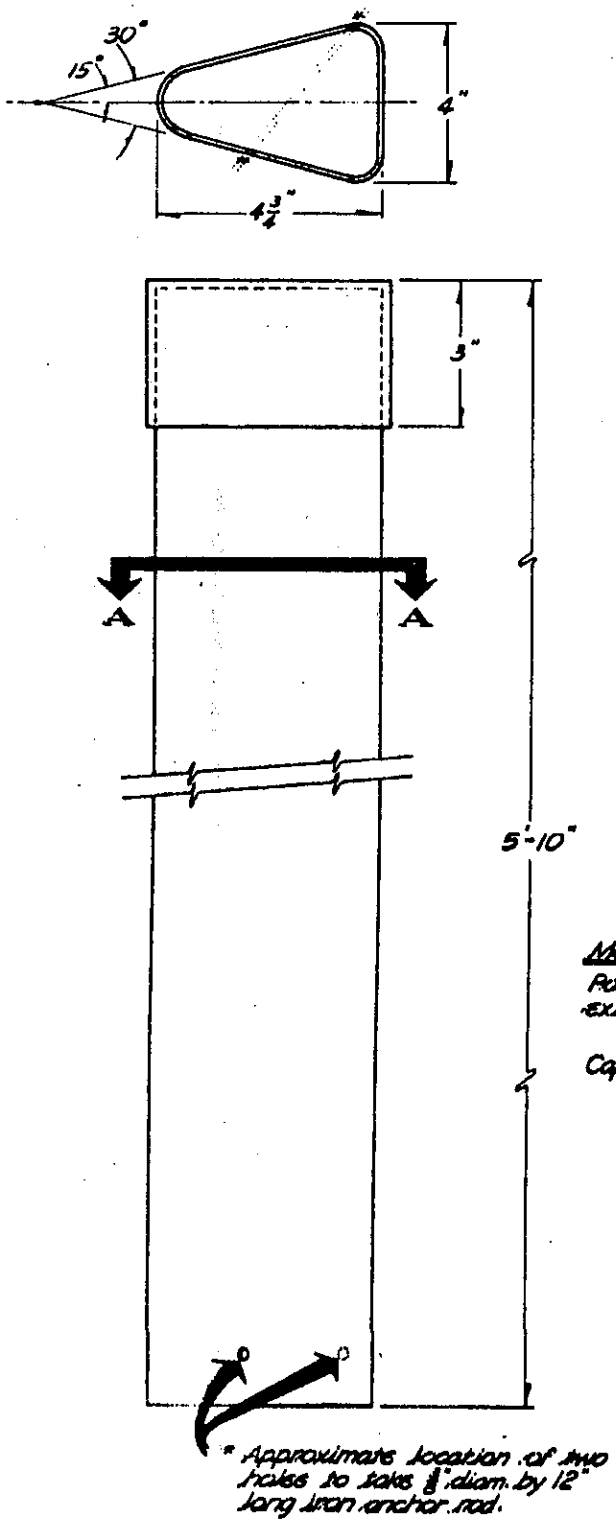

Material:

Post: Seamless, white polyethylene extrusion with 5/32" thick walls.

Cap: Slip-lock secured black polyethylene.

SYROFLEX
FLEXOPOST

STATE OF CALIFORNIA — DEPT. OF TRANSPORTATION
OFFICE OF BUSINESS MANAGEMENT
MATERIEL OPERATIONS

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

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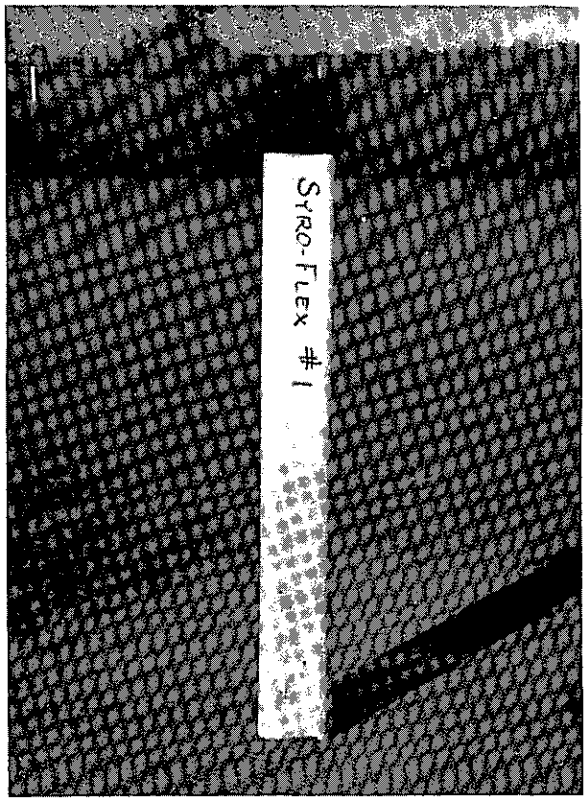
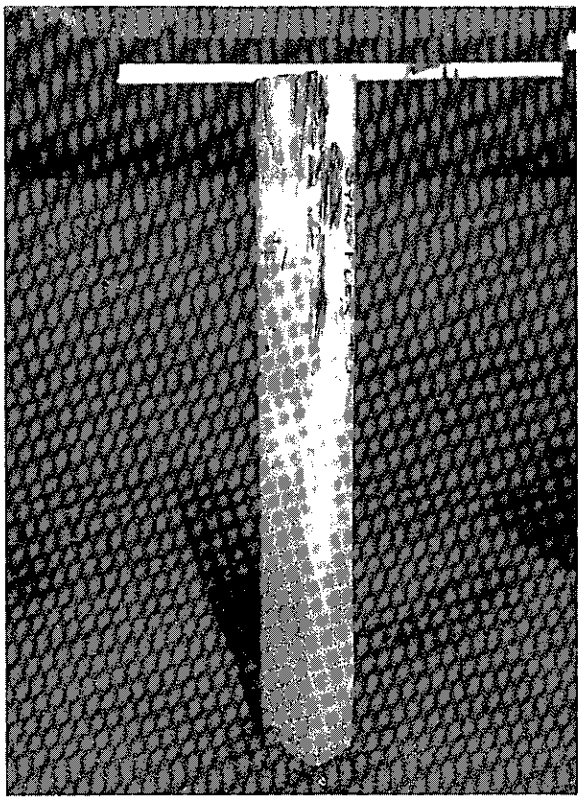
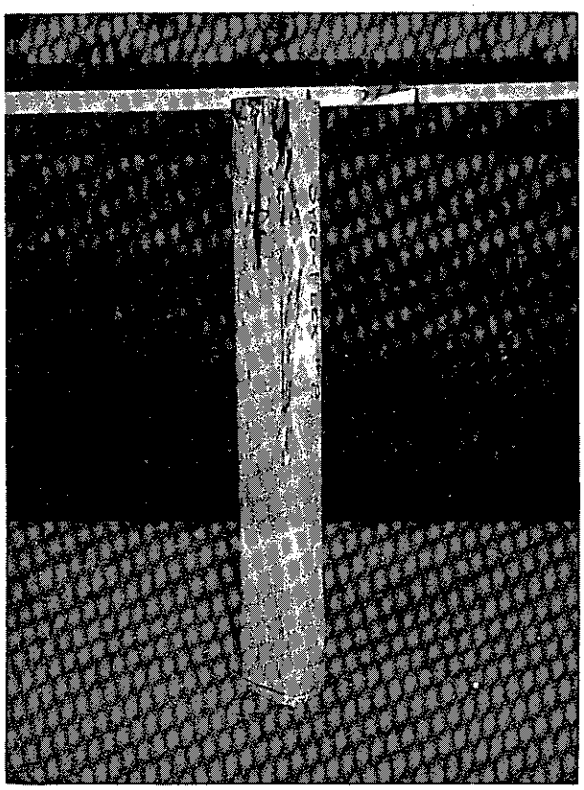
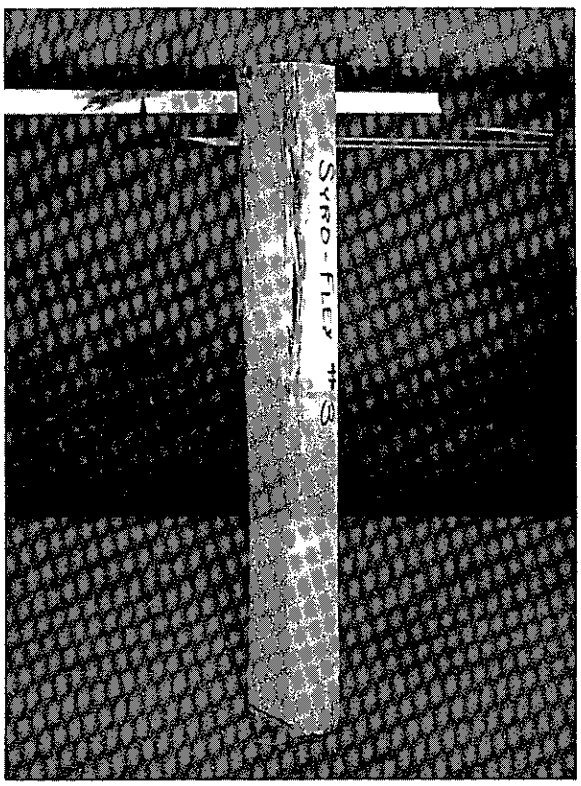
Figure 8









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D. Polypost Guide Marker Post

We have been informed that thousands of Polypost guide marker posts have been installed in Canada; however, no installations have been made to date in California. This post was tested for vehicular impact performance on February 14, 1977, and again on April 29, 1977.

This post is fabricated out of a white flexible plastic with a 10" long black flexible plastic top. It is circular in cross section with a 3 1/2" diameter. Details of the Polypost are shown in Figure 9. This hollow post is a non-driveable type which requires a hole in the ground and backfilling both inside and out to ground level. The upper left photo in Figure 10 shows one of the three posts before impact and the other photos show all three posts after 10 vehicular impacts. The interior of all three posts were backfilled.

The second series of tests was conducted to verify the manufacturer's claim that the post would perform satisfactorily without interior backfilling. This installation was not successful. The guide marker post failed to return to vertical when the interior backfill was omitted.

There was slight or no damage to the vehicle from the 55 mph impact into this backfilled guide marker post. The post was able to withstand the 10 vehicular impacts and return to a vertical position with little or no apparent damage. Care must be taken to insure the backfill is tightly compacted for this post as anchorage depends entirely on the friction between the post and the soil. Two of the three posts pulled out of the ground 4" to 6" from the impacts. The third post pullout was very minimal. Approximately 1/2" or so. It was found during the second test series that the post would not

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return to a vertical postion unless the interior of the post was backfilled as called for in their method of installation even though their representative claimed it would work satisfactorily without the backfill.

Samples of this guide marker post have been placed on the roof of the Transportation Laboratory to evaluate its durability in outdoor weather and exposed sunlight. Also, samples have been placed in the fadeometer and subjected to an accelerated exposure of ultraviolet light. These exposed specimens will be tested for loss in elongation and tensile strength during the exposure tests.

It is recommended that this post be considered acceptable at this time and further evaluated by trial field installations to be monitored for long term serviceability and general performance. Our present specification for non-driveable flexible guide markers is appropriate and should be used in specifying the Polypost guide marker post.

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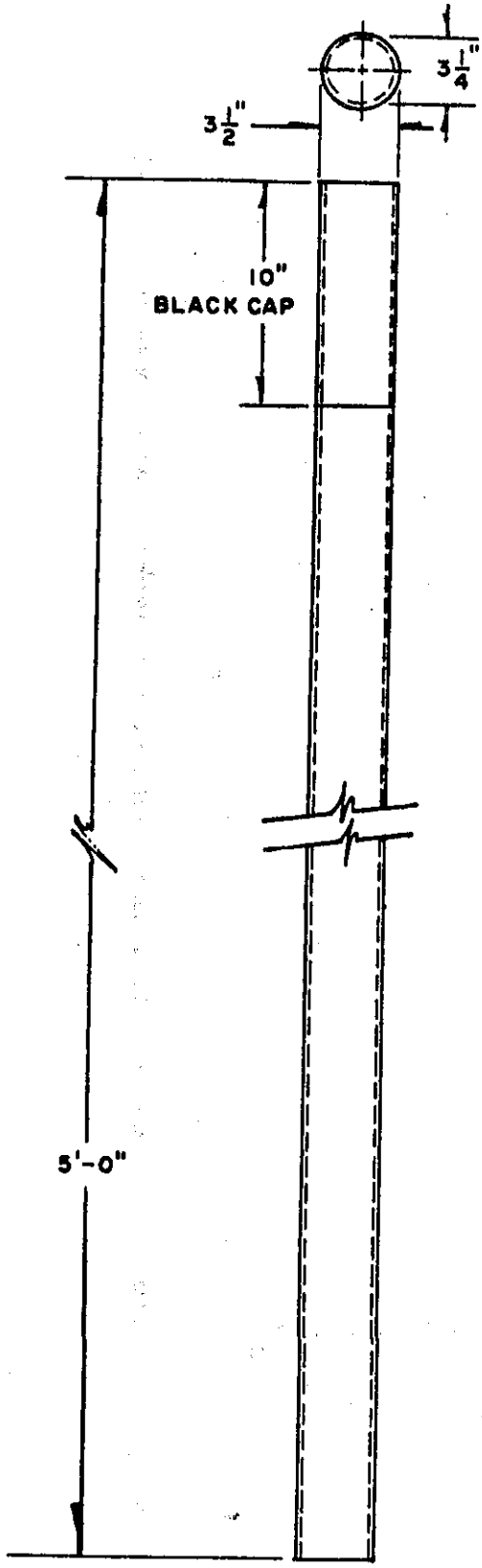

POLYPOST

FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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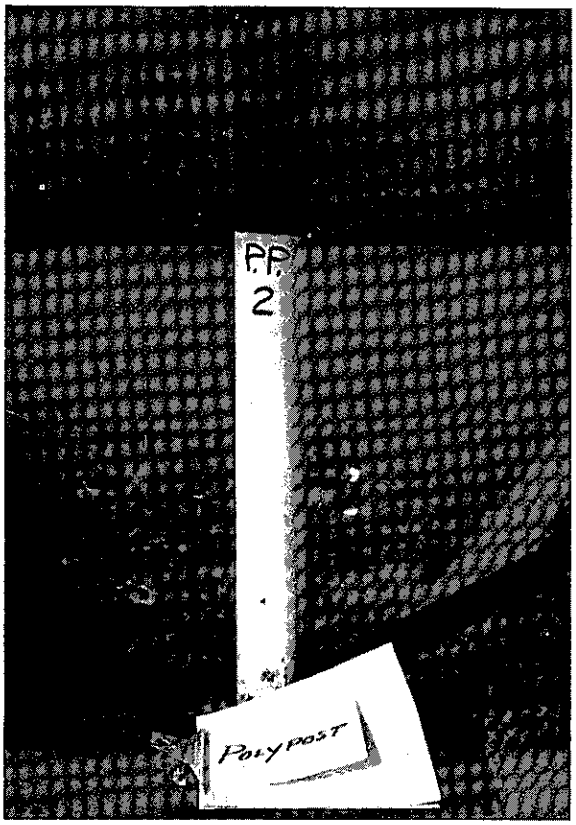
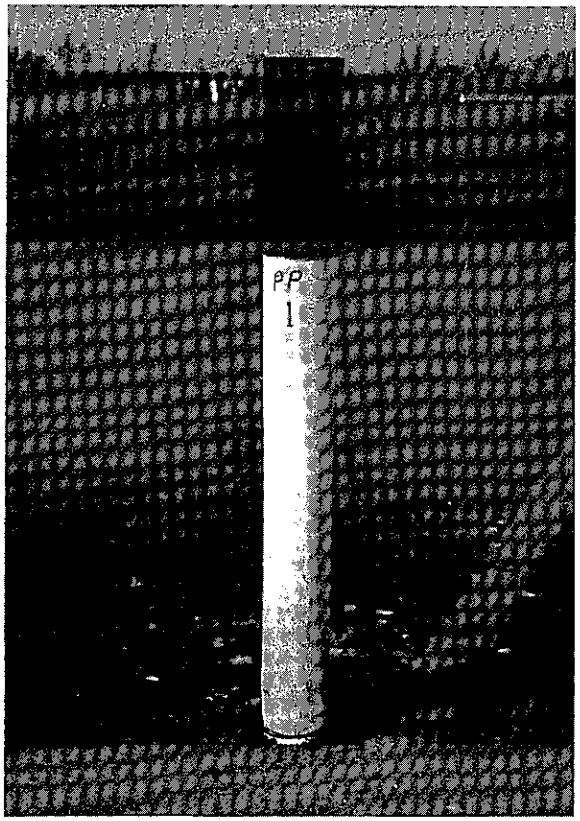
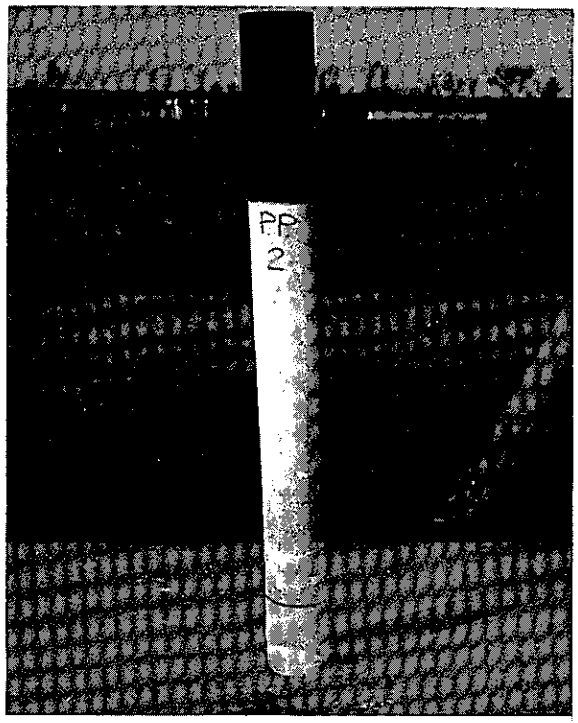
Figure 10







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E. Guardian Guide Marker Post

The Guardian flexible guide marker post was tested on April 29, 1977, for its ability to withstand repeated vehicular impacts at 55 mph. This post is fabricated of a relatively hard but flexible polycarbonate plastic. The manufacturer claims that ultraviolet light inhibitors have been incorporated into the plastic which assures little or no affect from ultraviolet light and claims it to be durable in weathering with a long predicted service life. The guide marker has a 3 1/2" face and is constructed by two pieces which are riveted together as shown in Figures 11 and 12. The two pieces work together in providing the required stiffness to maintain a stable vertical member. The manufacturer indicated that this is a semi-driveable flexible guide marker post which would require a special spade or tool to make a pilot hole in the ground first to drive it into the ground. We did not develop a means of driving this guide marker in place in this study and therefore classify it as a non-driveable type. This guide marker would not require interior backfilling.

Damage to the vehicle at 55 mph by this guide marker was minimal to slight. However, the rivets which held the two sections of the post together separated upon the first impact of the vehicle. The top portion of the post cracked and subsequently broke apart from further repeated vehicle impacts. In its present design form we would not consider this post to be acceptable for installations in areas subjected to repeated vehicular impacts. However, the manufacturer of this post may be able to develop a better method of fastening the two pieces of this post together. Therefore, due to the fact that this polycarbonate flexible guide marker may have possibilities with design improvement, it is being further evaluated for weathering and the effects of ultraviolet light. Pieces of the marker have been placed on the roof of the Laboratory for outdoor weathering and exposure and in the fadeometer for accelerated ultraviolet light exposure.

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It is recommended that no further evaluation than mentioned above be conducted on this post unless design changes are made.

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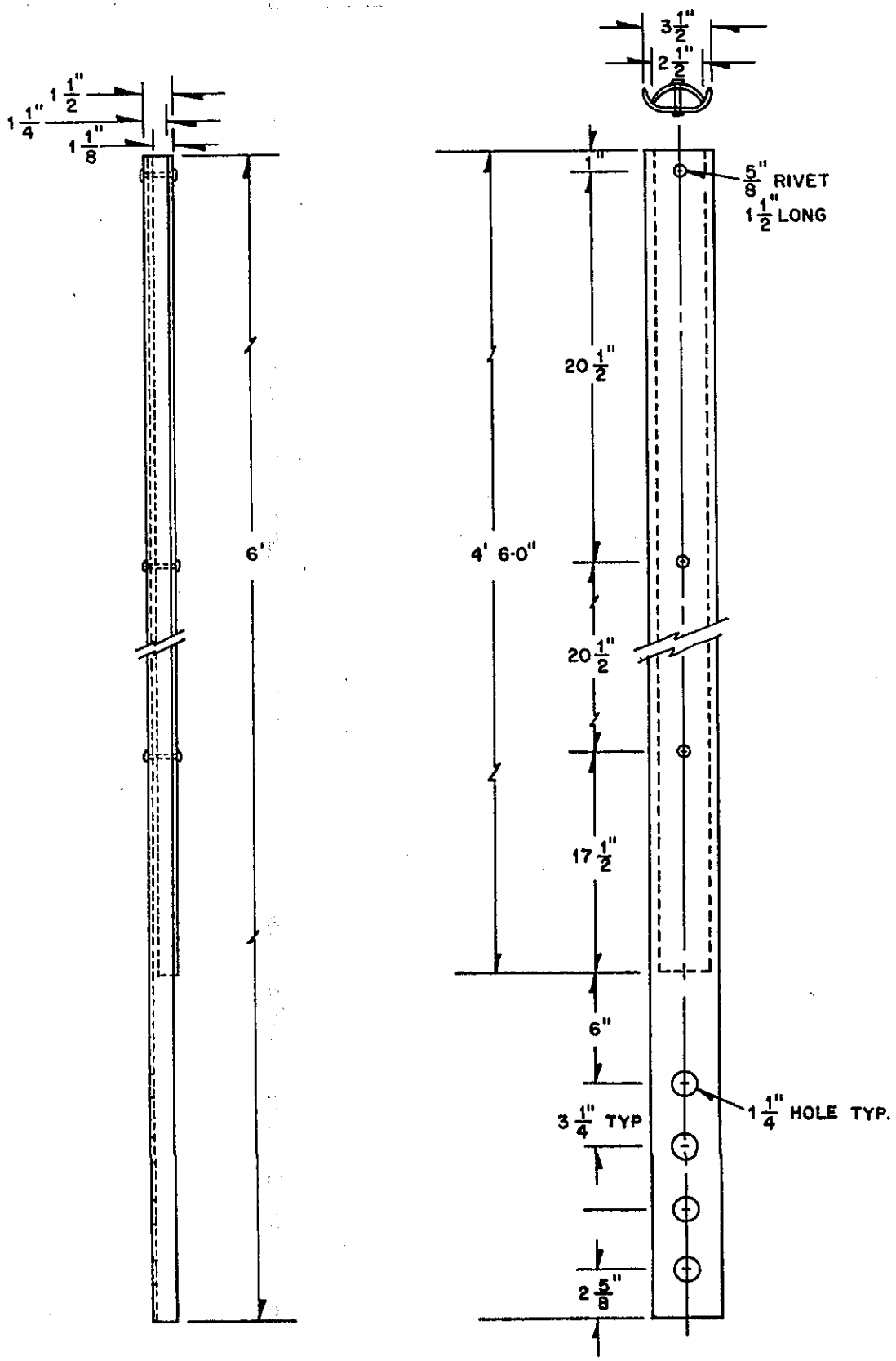
Figure 11



"GUARDIAN"

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

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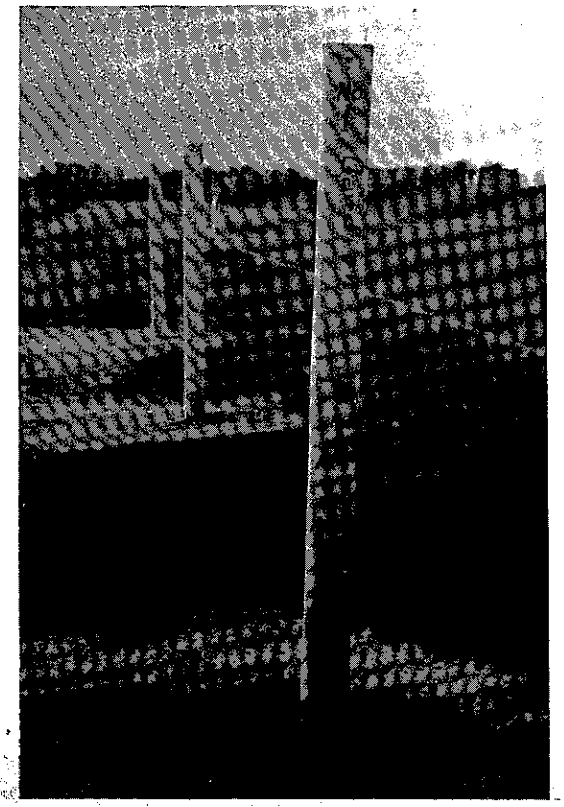
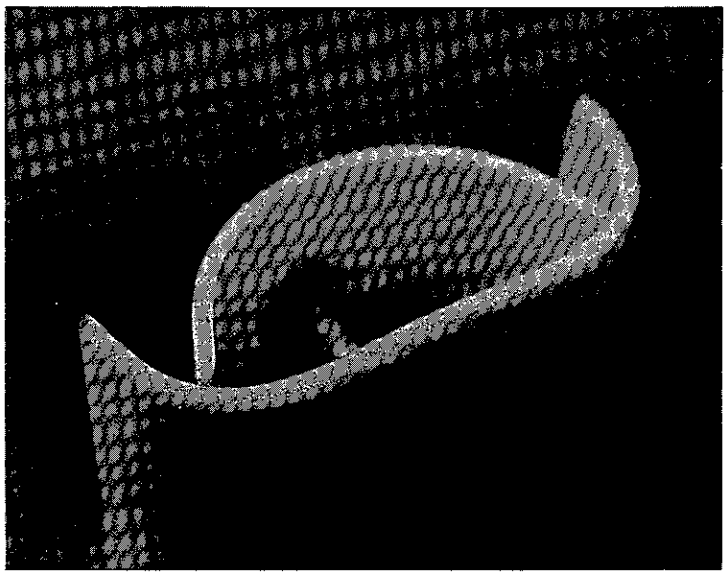
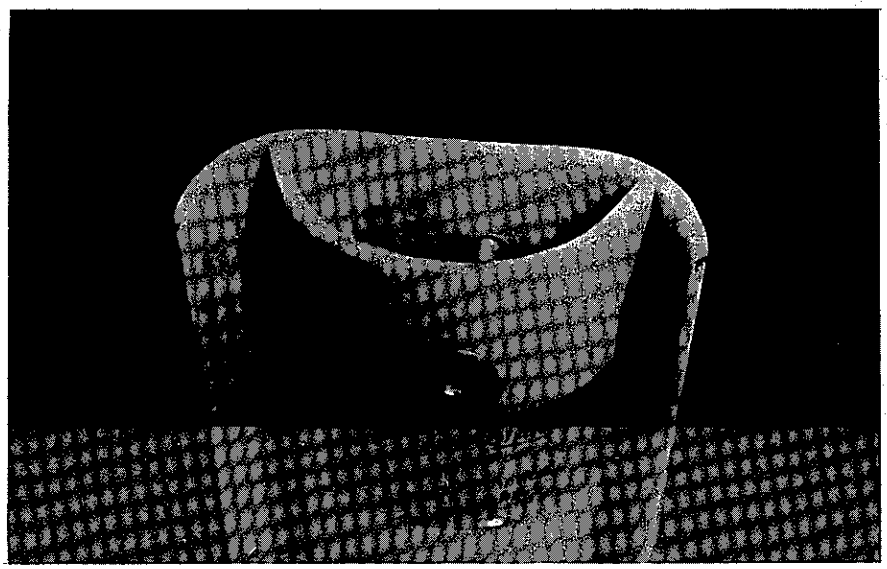
Figure 12

GUARDIAN MARKER POST







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F. Carsonite Guide Marker Post

The Carsonite flexible guide marker post was tested on February 14, 1977, and again on April 29, 1977, both tests being conducted at the Translab dynamic test site at the Highway Patrol Academy. It was tested again on May 25, 1977, outside of Carson City by the manufacturer. This test was witnessed by Laboratory and the Office of Traffic personnel.

The Carsonite flexible delineator is truly a driveable system. It can be installed by methods similar to those employed to install the steel post used for guide marker posts. This post consists of a composite material fabricated from fiberglass, pulverized marble, and resin. The glass fibers are oriented to provide optimum flexural strength to resist vehicular impact.

Several major modifications have been made to the marker from its inception to the design tested in the last series of tests conducted by the manufacturer. For the first test series, on February 14, 1977 by the Transportation Laboratory, there were two designs: one consisted of a T section with a face width of 2 1/2" and a web width of approximately 3/4". Figure 13 shows the details of this post. Figure 14 includes photos of the Carsonite T-post. This model was developed from an earlier model that had a face width of approximately 1". The 1" wide model was never evaluated nor considered a likely candidate for a flexible guide marker.

The second design tested in the first series consisted of a flat 2 1/2" wide flexible guide marker with a rib for stiffness and strength along both edges as well as similar raised rib centered on the back of the marker. Figure 16 includes photographs of the 2 1/2" Carsonite ribbed post.

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A third design tested in a second series on April 29, 1977 by the Laboratory consisted of a flat 3 3/4" wide ribbed post. This shape is the final and acceptable design and is detailed on Figure 15 and pictured in photos on Figure 18.

The final tests performed by the manufacturer on May 25, 1977 were on the 3 3/4" ribbed post design except the pigmentation in the post was changed with the aim of providing more flexibility to resist the bending encountered from vehicle impact.

During the entire vehicle impact test series, there was slight if any damage to the vehicle when encountering any of the posts at speeds up to 55 mph. The first Carsonite T-post design (2 1/2" face with 3/4" web) was considered by the manufacturer to be functionable only at slower impact speeds of 20-30 mph. Therefore, the first tests conducted by the Transportation Laboratory on this design were at a speed of 35 mph. When impacted, the spline or web section of the T would separate on split from the flange or face. With this separation, the rigidity of the post was lost and its function in the field was questioned, particularly in high winds when both pieces are free to move and flop about. Objectionable as this was, the post could be impacted several times and still remain in an upright position. After more than 5 impacts, the top of the guide marker began to fray and develop an objectionable and ragged appearance. It appeared that 5 impacts would be a reasonable-limit to expect for this post, as compared to the 10 impacts withstood by the non-driveable flexible posts.

The initial test on the 2 1/2" wide ribbed flexible guide marker post, which the manufacturer claimed could withstand the higher impact speed of up to 55 mph resulted in a post failure at that speed. The impact sheared the post off at the ground level as shown in photos in Figure 17. However, when the

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test was rerun at a slower speed of 35 mph, this ribbed post withstood the impact and returned to a vertical position. Once a plastic hinge formed at the base of the post from the first slower vehicular impact, the post was able to withstand much higher speeds, up to 55 mph in subsequent tests.

The 3 3/4" wide ribbed post, was tested in the Laboratory second test series with the first and second vehicular impact speed of 35 mph without any failures. Then the impact speed was increased to 55 mph which the posts also withstood.

The third test, conducted by the manufacturer in Carson City, on 3 3/4" wide ribbed posts which incorporated all the new features discussed earlier including the change in pigmentation, demonstrated that the post could be flexible and reliable. To increase the reliability of the post's performance, it is important that provision is made for a radius in the supporting foundation at the interface of the post and the surface. This radius serves as a hinge point for the post. Noting the photos in Figure 17, the 2 1/2" ribbed post were installed in a very hard clay in a small diameter hole drilled through asphaltic concrete. This installation and speed did not allow a sufficient radius to develop for the stiffer post as it bent at the top of the supporting surface thus they failed. Referring to Figure 18, the top left photo shows the required type of radius needed in the surface of the ground to enable the post to bend without breaking. Provisions for this should be provided during the installation which can be accomplished by digging out a little material in front of the marker.

The manufacturer also demonstrated comparable ease in driving the post as shown in photos in Figure 18. This demonstration consisted of driving both a steel post and the Carsonite post. The bottom right picture shows the two operations installing the two types of posts.

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The upper right picture shows the appearance of the top of the ribbed post after 10 vehicular impacts. The first impact was at a speed of 35 mph. The subsequent 9 impacts, after the plastic hinge had been developed in the lower speed impact, were at 55 mph. Even though the post was still standing vertically, we would consider its frayed end condition unacceptable. However, in the first 5 impacts, there was no appreciable fraying or separation of the component parts of the post as developed in the next 5 impacts.

From the impact testing performed to date on the flexible delineator post, it appears that for the post to withstand 55 mph impacts without failure, a plastic hinge must be developed in the post at ground level. This can be accomplished by bending the post to the ground by a slow speed impact or other effective methods. Thus the installation instructions should include the requirement for a radius in the soil or other supporting material at the post-surface interface, and in addition the development of a plastic hinge in the post at the same location.

Portions of a Carsonite flexible guide marker post have been placed on the roof for outdoor weathering and in the fadeometer for accelerated ultraviolet durability.

It is recommended that the latest design of the Carsonite post be considered acceptable for trial installations and further recommend that installation of the posts be monitored for a period of time to determine their performance and identify problems associated with them. A suggested specifications for driveable flexible plastic guide marker and clearance marker posts is attached.

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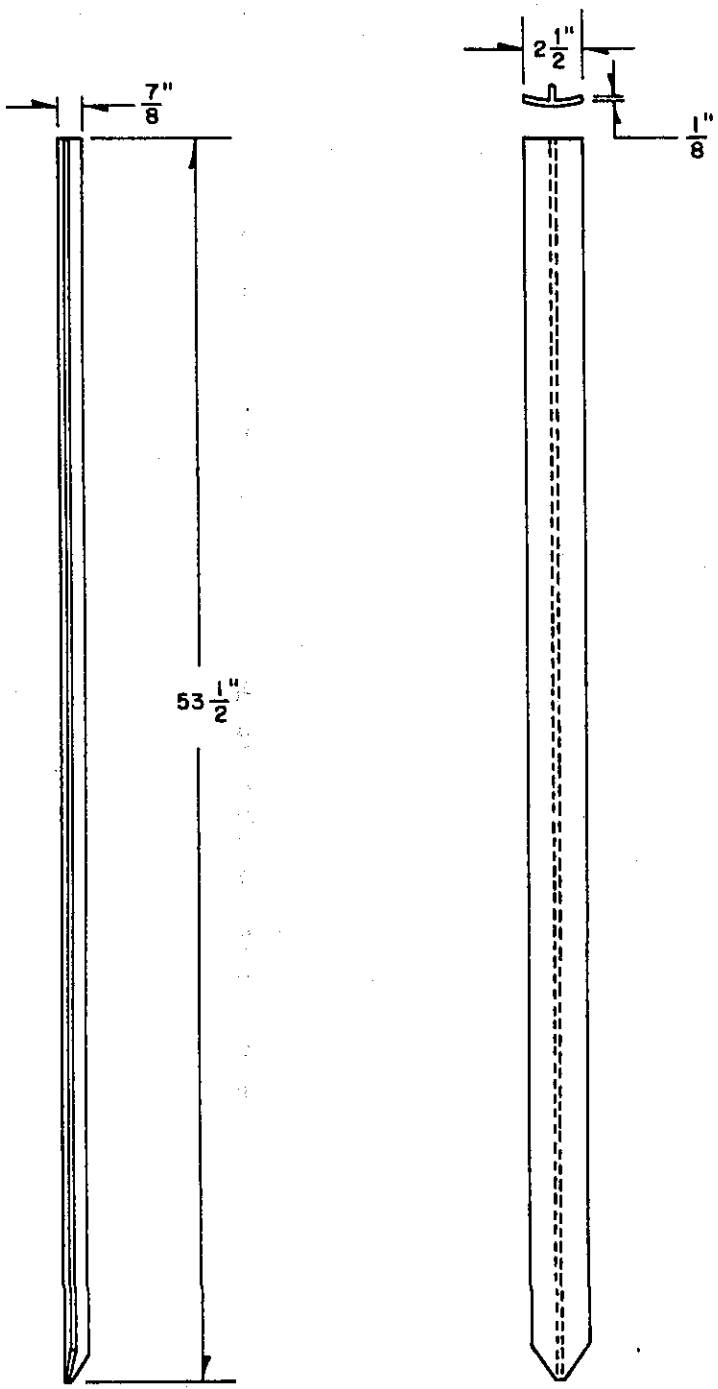

CARSONITE "TEE"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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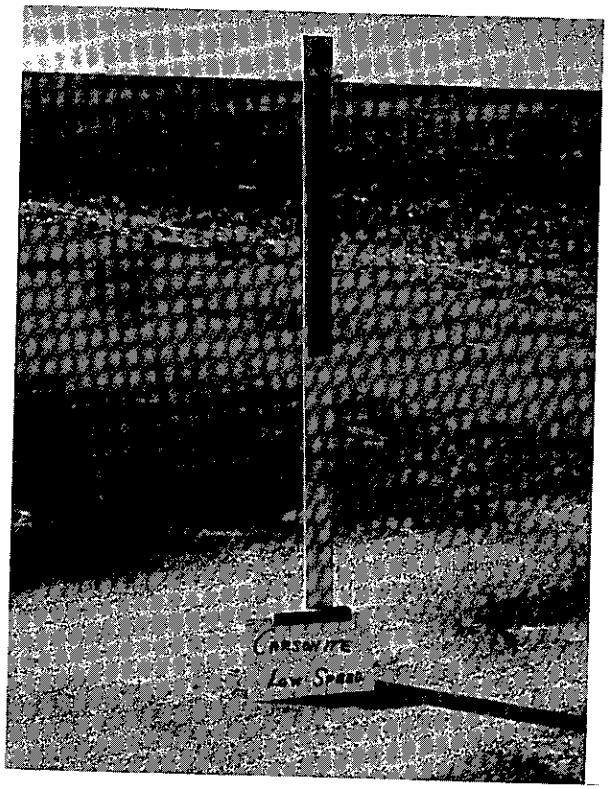
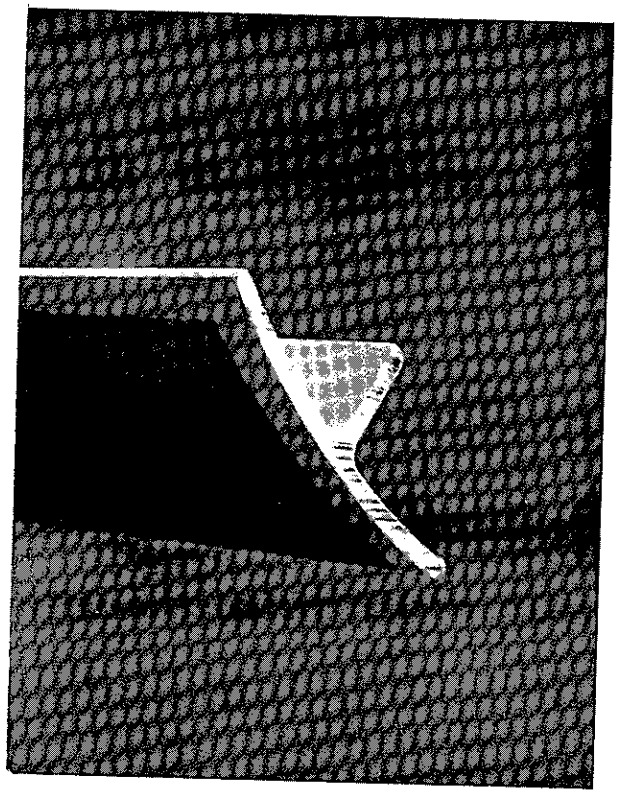
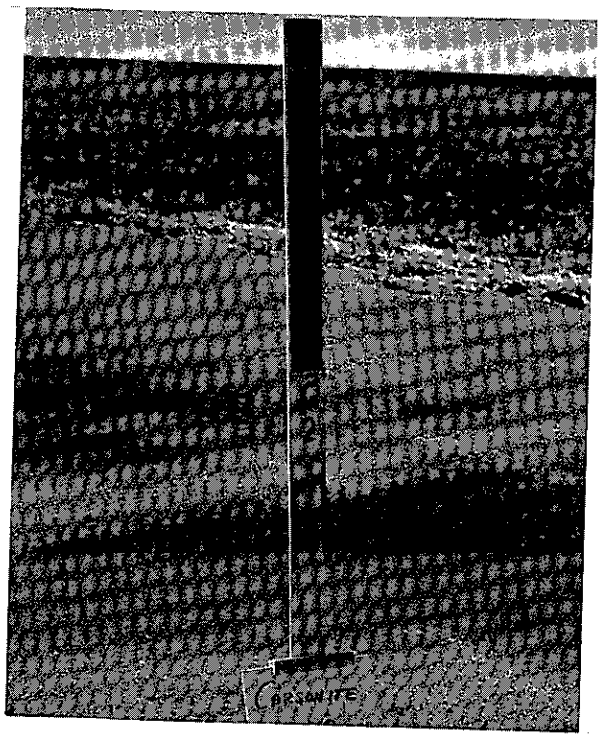
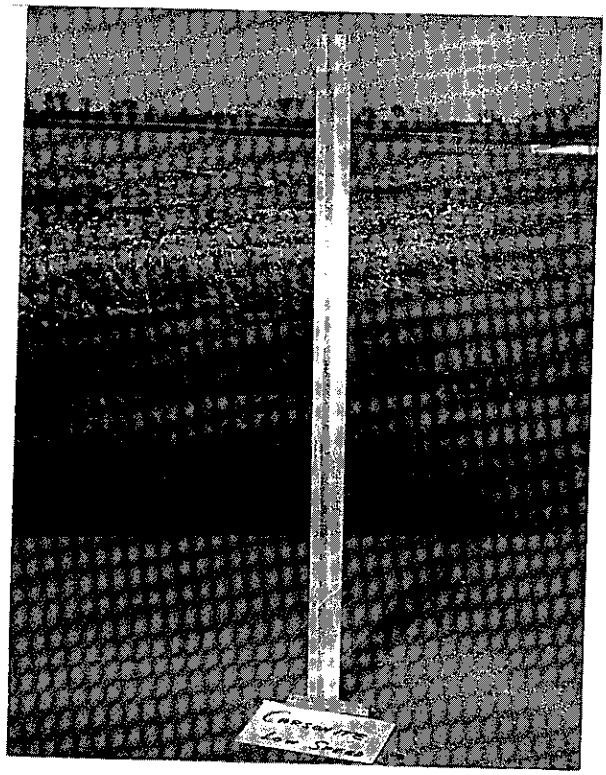
CARSONITE T-POST

Figure 14









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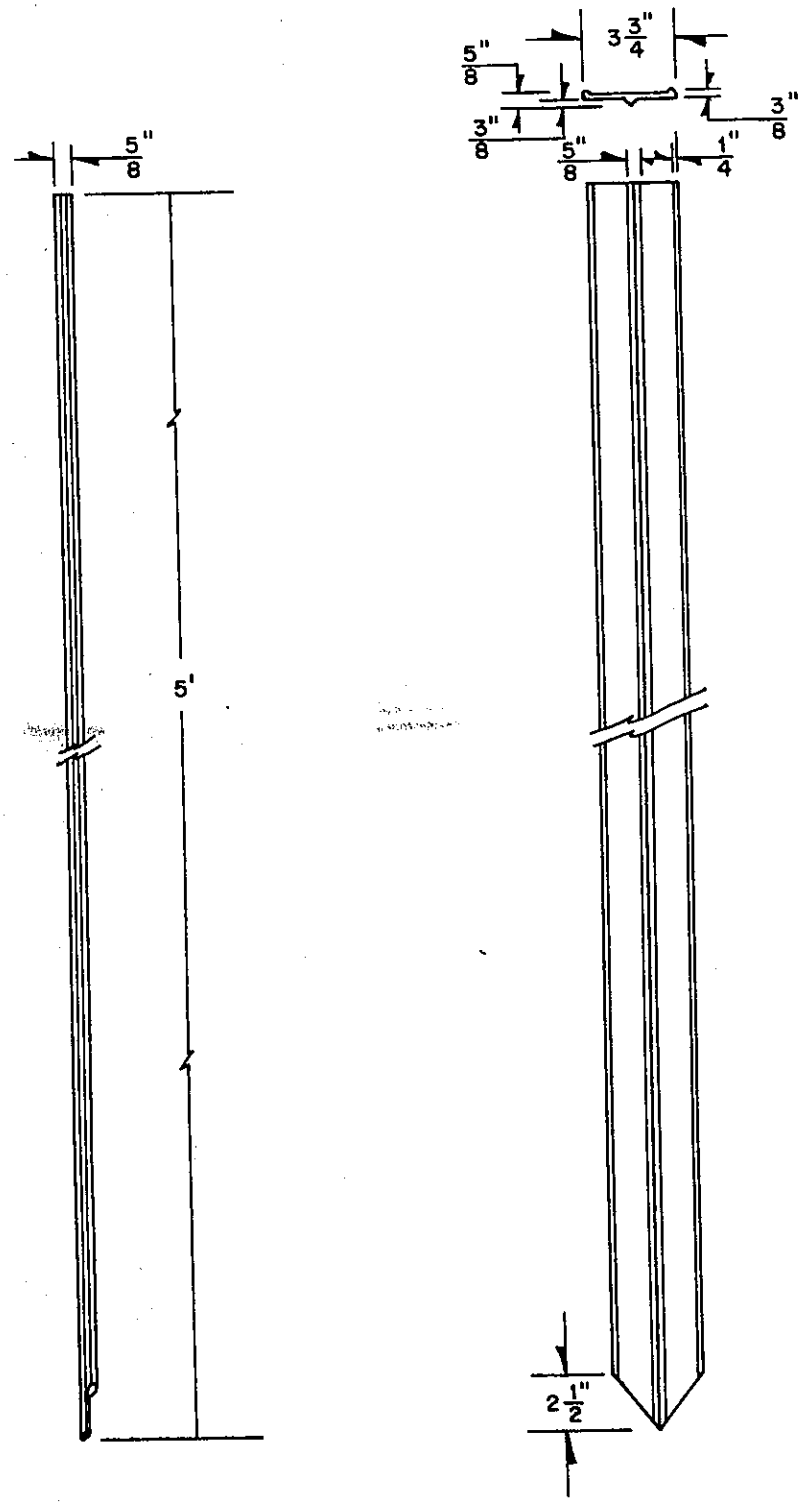

CARSONITE "RIBBED"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

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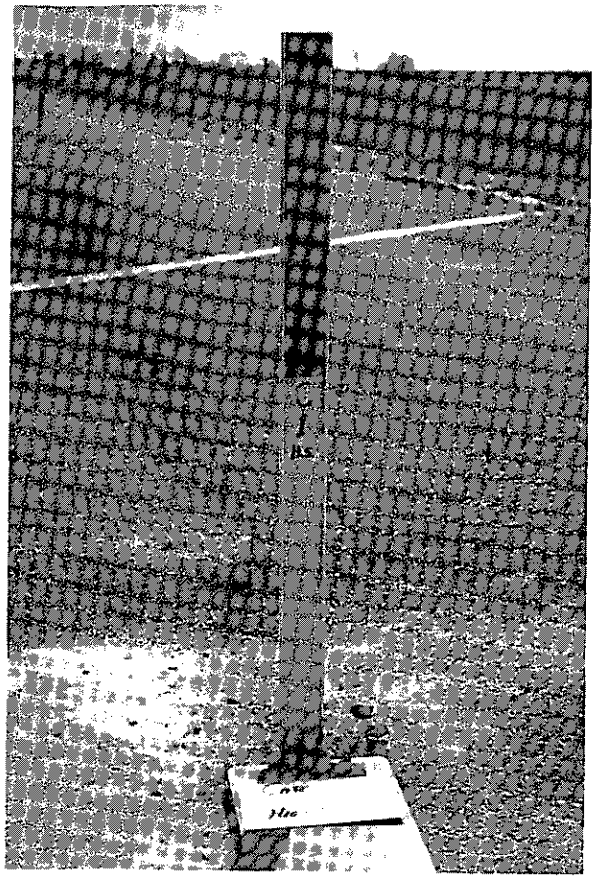
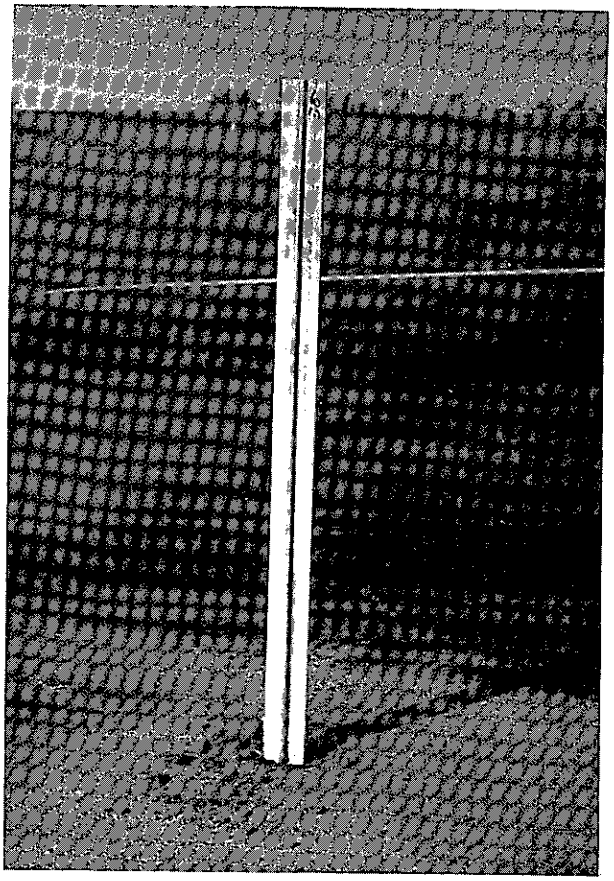
CARSONITE RIBBED POST

Figure 16





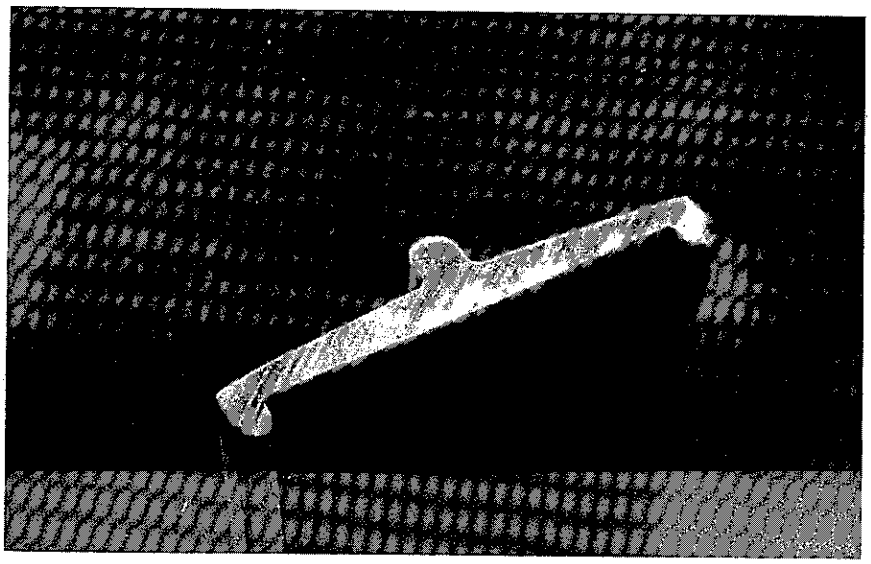


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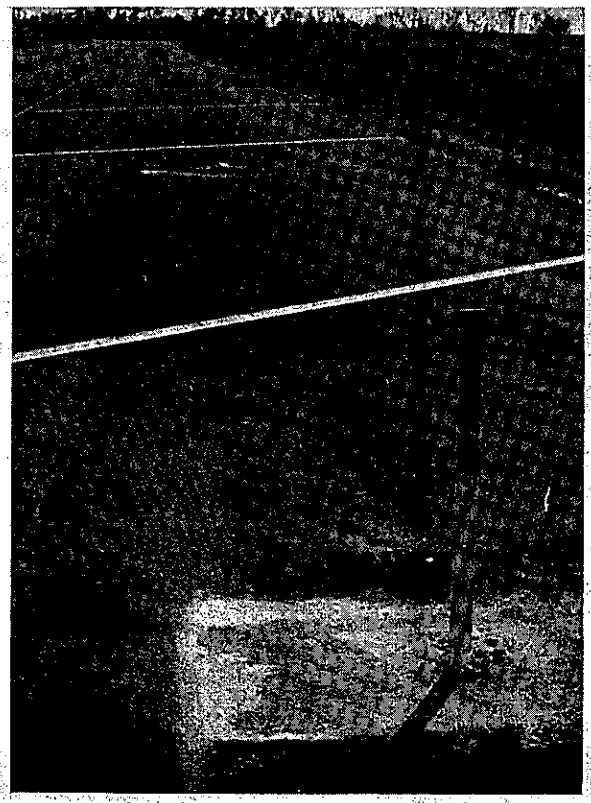
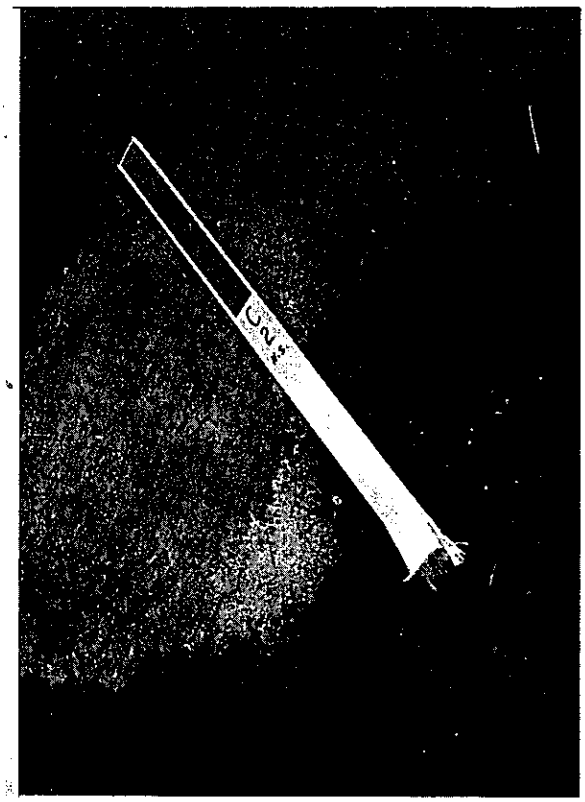
Figure 17

CARSONITE RIBBED POST





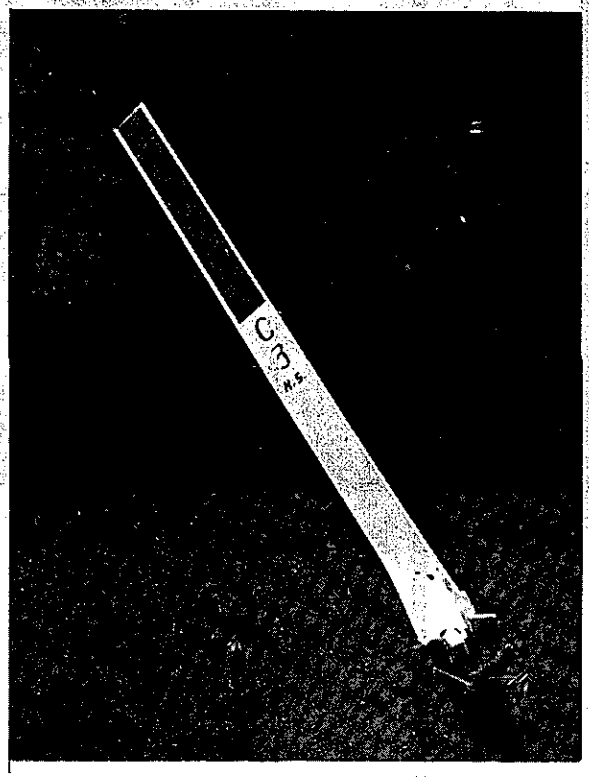


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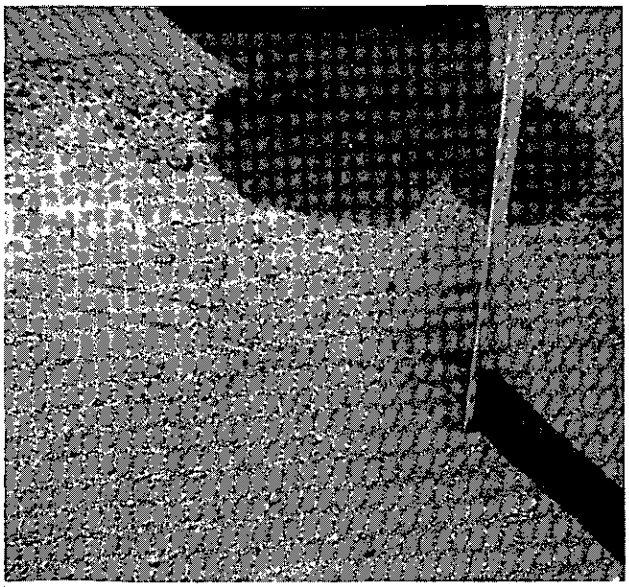
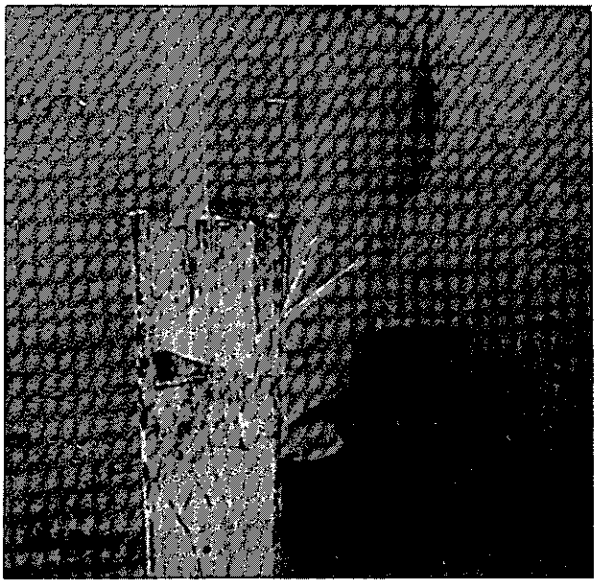
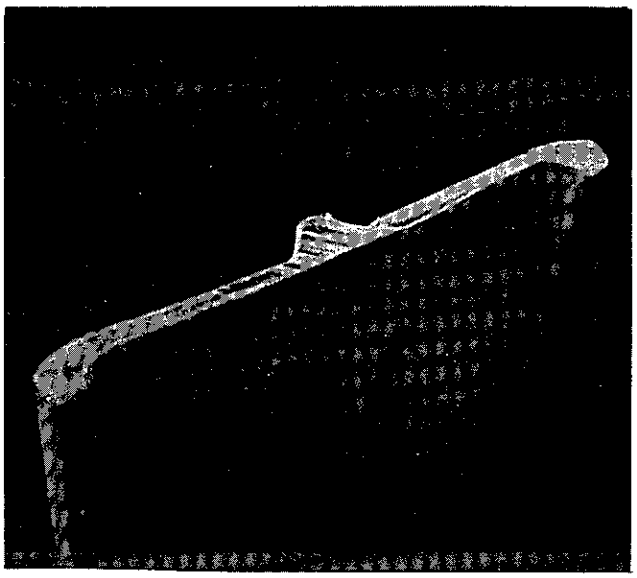
Figure 18

CARSONITE RIBBED POST







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VI. APPENDIX

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY

SUGGESTED SPECIFICATIONS FOR DRIVEABLE FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POST

I. SCOPE

These specifications define requirements for driveable flexible plastic highway guide marker and clearance marker posts which are designed for installation with a post hammer.

II. GENERAL

A. Material

The material shall be of a durable white plastic which shall be resistant to impact, ultra violet light, ozone, and hydrocarbons.

B. Workmanship

The post shall exhibit good workmanship and shall be free of burns, discoloration, contamination, and other objectional marks or defects which affect appearance or serviceability.

C. Manufacturer's Quality Control

No later than ten days prior to fabrication of the marker post the Contractor shall submit a copy of the manufacturer's quality control program to the Transportation Laboratory for review and approval. The quality control program shall include, but not necessarily be limited to, the following items:

(1) Bases of acceptance of incoming or raw materials.

(2) The types, methods and frequencies of control test.

(3) Where and how the quality control data is recorded; QC charts, log books, etc.

(4) Where and how the final inspection is made.

(5) Identification of the person responsible for quality control and his authority in the organization.

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III. GENERAL REQUIREMENTS

A. Dimensions

1. Width

The post shall have a minimum target area of 120 square inches and a minimum width of 3 inches facing traffic.

2. Length

The post shall be of such length to provide a height of 36 to 48 inches above the ground surface as determined from the California Standard Plans for Guide Markers, to provide the minimum specified target area and to provide the required anchoring depth as specified under Section III.B. of these specifications.

B. Base Anchoring

The post shall be designed to facilitate a permanent installation which shall resist overturning, twisting, and displacement from wind and impact forces. The post shall be designed for an anchoring depth of 18 inches to 24 inches. Detailed installation instruction shall be provided by the manufacturer.

C. Color

The post shall be opaque white. The yellowness index shall not exceed 7 when tested in accordance with ASTM Designation: D 1925 or E 313. The daylight 45°, 0° luminous directional reflectance shall be a minimum of 70 when tested in accordance with ASTM Designation: E 97.

D. Physical Properties and Performance

1. Heat Resistance

The post shall be conditioned a minimum of 2 hours in an oven at 140 ± 3°F. The conditioned post shall be capable of straightening itself within 30 seconds when bent 180° at the midpoint for each of 4 bends. The test on each post shall be completed within 2 minutes of removal from oven.

2. Cold Resistance

The post shall be conditioned a minimum of 2 hours at -5 ± 3°F in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber.

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a. The post shall not be adversely effected when a person, standing approximately at the center of the post, bends the free half of the post to a 90° angle with the remaining section being stood upon. The post shall return to its original shape within 60 seconds for each of four separate bends.

b. A steel ball weighing 2 pounds shall be dropped a distance of 5 feet through a virtually frictionless vertical guide to impact the surface of the post. The surface of the post being struck by the steel ball shall be in a horizontal position, with the post supported and held in position at both ends. The post shall be subjected to 5 impact tests concentrated near the middle of the post. Fracturing, cracking, or splitting of the post shall constitute failure.

3 Colorfastness

The post materials shall be exposed for 1000 hours in an Atlas Type B or BH Xenon Arc Weatherometer (ASTM G26) with no significant yellowing or darkening.

4. Impact Resistance

The post shall be manufactured from an impact resistance material so that an installed post is capable of self erecting and withstanding 5 vehicle impacts at temperatures of 40°F or above without loss of serviceability. The first vehicle impact shall be at the speed of 35 mph and the remaining 4 impacts shall be at the speed of 55 mph. Little or no damage shall be caused to the impacting vehicle. The vehicle shall be a typical American-made sedan with a weight of 4,000 ± 1,000 pounds.

IV. REFLECTORS

A. Description

The reflector shall be of impact resistant retroreflective sheeting which shall be subject to approval by the California Department of Transportation Laboratory. Each reflector shall have a minimum projected area of 12 square inches ± 1 square inch.

B. Mounting

The reflectors shall be mounted on the top 11 inches of the post with the reflectors facing in the direction of the oncoming traffic. The reflectors shall be mounted by an approved positive means which has adequate strength to prevent loss of the reflector during the life of the post.

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C. Reflective Intensity

The reflective sheeting shall meet the following minimum values at a .2 degree angle of divergence, expressed in units of candlepower per foot candle per square foot as measured from a distance of 50 feet between the reflector and light source. The brightness value shall be determined by California Test Method No. 642. The wet reflectance values shall not be less than 90 percent of the dry values when tested in accordance with the Federal Highway Administration Standard Specification FP-74, Section 718.01(b).

MINIMUM DRY REFLECTIVE INTENSITY VALUES

Divergence Angle ( )	Incidence Angle ( )	Silver White	Yellow	Red	Orange
0.2	- 4	250	150	40	60
0.2	+15	185	110	30	45
0.2	+30	60	35	10	16

D. Color

The color of the reflective sheeting shall conform to either the Chromaticity Coordinates specified in the Federal Standard Specification FP-74, or the PR Color Number specified by the Federal Highway Administration's Color Tolerance Chart.

The instrumental method of determining color shall conform to the requirements specified in the Federal Specification FP-74. In the event of any dispute concerning the test results of instrumental testing, the visual test shall prevail.

A significant difference between day and night reflective color shall be grounds for rejecting the reflective sheeting.

E. Specular Gloss

The reflective sheeting shall have an 85° specular gloss of not less than 40 when tested in accordance with ASTM D523.

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V. PREREQUISITE TO QUALIFICATION

Before any manufacturer's post can be qualified for bidding, he shall submit a certified test report and test data, developed by an approved testing laboratory which attests to the fact that their marker post complies in all respects with the requirements covered in this specification.

VI. SAMPLING AND ACCEPTANCE

A. Sampling

Posts shall be sampled and tested, prior to shipment, by the California Department of Transportation Laboratory. A sample shall consist of four randomly selected posts for lot quantities up to 1000. For lots larger than 1000, an additional post shall be sampled for each additional 500 posts or fraction thereof. A resample will consist of twice as many posts as originally sampled. The lot size shall not exceed 5000 posts. Delivered posts are also subject to inspection sampling and testing for compliance with these specifications.

B. Acceptance

100 percent of the original sampling of each lot of posts shall comply with all requirements. A resample of the lot will be allowed at the request of the contractor when at least 75 percent of the original sample complies with all requirements. Any resampling will be charged to the contractor at the current prevailing testing rate. Any failure in the resample will be cause for rejection of the entire lot or shipment and further sampling or testing will not be allowed; however, if all resamples pass the lot will be accepted.

VII. PATENTS

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, the Director of Transportation and their duly authorized representatives from all suits at law, or action of every nature for, or on account of, the use of any patented materials, equipment, devices, or processes.

NOTE:

To date only the following manufactured post shown on the attached drawings have been found to comply with these specifications:

1. Carsonite Post

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
OFFICE OF BUSINESS MANAGEMENT
MATERIEL OPERATIONS

SPECIFICATIONS FOR FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POST

I. SCOPE

These specifications define requirements for flexible plastic highway guide marker and clearance marker posts.

II. GENERAL

A. Material

The material shall be of a flexible white plastic which shall be resistant to impact, ultra violet light, ozone, hydrocarbons, and shall resist stiffening with age.

B. Workmanship

The post shall exhibit good workmanship and shall be free of burns, discoloration, contamination, and other objectional marks or defects which affect appearance or serviceability.

C. Manufacturer's Quality Control

No later than ten days prior to fabrication of the marker post the Contractor shall submit a copy of the manufacturer's quality control program to the Transportation Laboratory for review and approval. The quality control program shall include, but not necessarily be limited to, the following items:

(1) Bases of acceptance of incoming or raw materials.

(2) The types, methods and frequencies of control test.

(3) Where and how the quality control data is recorded; QC charts, log books, etc.

(4) Where and how the final inspection is made.

(5) Identification of the person responsible for quality control and his authority in the organization.

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III. GENERAL REQUIREMENTS

A. Dimensions

1. Width

The post shall have a minimum target area of 120 square inches and a minimum width of 3 inches facing traffic.

2. Length

The post shall be of such length to provide a height of 36 to 48 inches above the ground surface as determined from the California Standard Plans for Guide Markers, to provide the minimum specified target area and to provide the required anchoring depth as specified under Section III.B. of these specifications.

B. Base Anchoring

The post shall be designed to facilitate a permanent installation which shall resist overturning, twisting, and displacement from wind and impact forces. Soil bedded type post shall be designed for an anchoring depth of 18 inches to 24 inches. Concrete or asphalt bedded types shall be designed for a minimum anchoring depth of 6 inches. Detailed installation instruction shall be provided by the manufacturer.

C. Color

The post shall be opaque white. The yellowness index shall not exceed 7 when tested in accordance with ASTM Designation: D 1925 or E 313. The daylight $45^{\circ},0^{\circ}$ luminous directional reflectance shall be a minimum of 70 when tested in accordance with ASTM Designation: E 97.

D. Physical Properties and Performance

1. Tensile Strength Properties

a. The post shall have a minimum tensil strength of 1100 pounds per square inch. The tensile stress shall be determined in accordance with "Standard Method of Test for Tensile Properties of Plastic", ASTM Designation D638 (Test Specimen Type 1). The rate of jaw separation shall be 20 inches per minute.

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2. Heat Resistance

a. The post shall be conditioned a minimum of 2 hours in an oven at 140 $\pm$ 3°F. The conditioned post shall be capable of straightening itself within 30 seconds when bent 180° at the midpoint for each of 4 bends. The test on each post shall be completed within 2 minutes of removal from oven.

b. The post shall be sufficiently rigid to resist wilting after conditioning a minimum of 2 hours at 180° $\pm$ 3°F.

3. Cold Resistance

The post shall be conditioned a minimum of 2 hours at -5 $\pm$ 3°F in an environmentally controlled test chamber. Testing shall be performed in the environmental chamber.

a. The post shall be sufficiently flexible to permit four 180° bends at the midpoint without cracking, each time straightening itself within 60 seconds.

b. A steel ball weighing 2 pounds shall be dropped a distance of 5 feet through a virtually frictionless vertical guide to impact the surface of the post. The surface of the post being struck by the steel ball shall be in a horizontal position, with the post supported and held in position at both ends. The post shall be subjected to 5 impact tests concentrated near the middle of the post. Fracturing, cracking, or splitting of the post shall constitute failure.

4. Colorfastness

The post materials shall be exposed for 1000 hours in an Atlas Type B or BH Xenon Arc Weatherometer (ASTM G26) with no significant yellowing, darkening, or loss of pliability.

5. Impact Resistance

The post shall be manufactured from an impact resistant material so that an installed post is capable of self erecting and withstanding 10 vehicle impacts at 55 MPH at temperatures of 40°F or above without breaking or loss of serviceability. Little or no damage shall be caused to the impacting vehicle. The vehicle shall be a typical American-made sedan with a weight of 4,000 $\pm$ 1,000 pounds.

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IV. REFLECTORS

A. Description

The reflector shall be of impact resistant retro reflective sheeting which shall be subject to approval by the Department of Transportation Laboratory. Each reflector shall have a minimum projected area of 12 square inches ± 1 square inch.

B. Mounting

The reflectors shall be mounted on the top 11 inches of the post with the reflectors facing in the direction of the on-coming traffic. The reflectors shall be mounted by an approved positive means which has adequate strength to prevent loss of the reflector during the life of the post.

C. Reflective Intensity

The reflective sheeting shall meet the following minimum values at a .2 degree angle of divergence, expressed in units of candlepower per foot candle per square foot as measured from a distance of 50 feet between the reflector and light source. The brightness value shall be determined by California Test Method No. 642. The wet reflectance values shall not be less than 90 percent of the dry values when tested in accordance with the Federal Highway Administration Standard Specification FP-74, Section 718.01(b).

MINIMUM DRY REFLECTIVE INTENSITY VALUES

Divergence Angle ( )	Incidence Angle ( )	Silver White	Yellow	Red	Orange
0.2	- 4	250	150	40	60
0.2	+15	185	110	30	45
0.2	+30	60	35	10	16

D. Color

The color of the reflective sheeting shall conform to either the Chromaticity Coordinates specified in the Federal Standard Specification FP-74, or the PR Color Number specified by the Federal Highway Administration's Color Tolerance Chart.

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The instrumental method of determining color shall conform to the requirements specified in the Federal Specification FP-74. In the event of any dispute concerning the test results of instrumental testing, the visual test shall prevail.

A significant difference between day and night reflective color shall be grounds for rejecting the reflective sheeting.

E. Specular Gloss

The reflective sheeting shall have an 85° specular gloss of not less than 40 when tested in accordance with ASTM D523.

V. PREREQUISITE TO QUALIFICATION

Before any manufacturer's post can be qualified for bidding, he shall submit a certified test report and test data, developed by an approved testing laboratory which attests to the fact that their marker post complies in all respects with the requirements covered in this specification.

VI. SAMPLING AND ACCEPTANCE

A. Sampling

Posts shall be sampled and tested, prior to shipment, by the California Department of Transportation Laboratory. A sample shall consist of four randomly selected posts for lot quantities up to 1000. For lots larger than 1000, an additional post shall be sampled for each additional 500 posts or fraction thereof. A resample will consist of twice as many posts as originally sampled. The lot size shall not exceed 5000 posts. Delivered posts are also subject to inspection sampling and testing for compliance with these specifications.

B. Acceptance

100 percent of the original sampling of each lot of posts shall comply with all requirements. A resample of the lot will be allowed at the request of the contractor when at least 75 percent of the original sample complies with all requirements. Any resampling will be charged to the contractor at the current prevailing testing rate. Any failure in the resample will be cause for rejection of the entire lot or shipment and further sampling or testing will not be allowed; however, if all resamples pass the lot will be accepted.

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VII. PATENTS

The Contractor shall assume all costs arising from the use of patented materials, equipment, devices, or processes used on or incorporated in the work, and agrees to indemnify and save harmless the State of California, the Director of Transportation and their duly authorized representatives from all suits at law, or action of every nature for, or on account of, the use of any patented materials, equipment, devices, or processes.

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