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Tests of Flexible Plastic Guide Marker and Clearance Marker Posts

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The flexible posts tested 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 back-filling.

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

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Tests Of Flexible Plastic Guide Marker And Clearance Marker Posts

REVISED
INTERIM REPORT
SEPT. 1978

Caltrans
CALIFORNIA DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

September 1978

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:

TESTS 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.

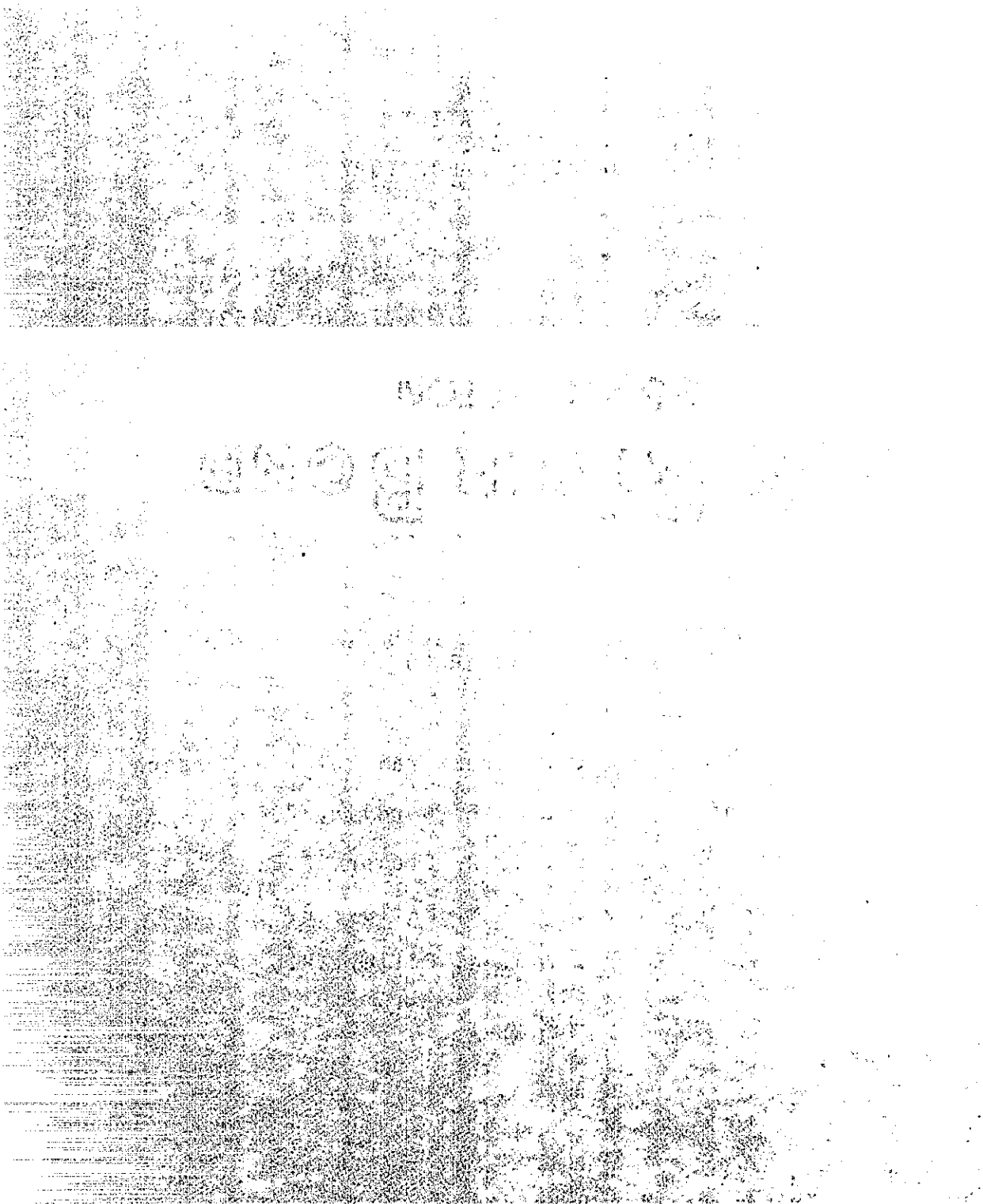
Very truly yours,

Neal Andersen

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

Attachment

SNB:lb



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Elmer Wrye - driver of the test vehicle plus aid in test installation

Vince Martin
Tom Ryan
Vince Bartley
Jim Keesling — test installation and evaluation

Bob Mortensen - photography

Appreciation is also due to various members from the Office of Business Management for their help in evaluating the guide marker posts during the vehicular impact test series.

Special thanks is due to the staff of the Offices of Traffic, Maintenance, Construction, and Districts 02, 06, 08, and 10 for their valuable input and technical assistance toward the development of specifications for flexible guide marker and clearance marker posts. The cooperation and assistance of industry representatives is also appreciated.

I. INTRODUCTION

The Transportation Laboratory was requested by the Office of Traffic (letter of December 15, 1976, C. P. Sweet, Jr. to G. A. Hill) to continue the evaluation of flexible guide marker posts. The initial evaluation of flexible guide marker posts was conducted by the Transportation Laboratory in 1971. A report entitled "An Evaluation of Seven Flexible Portable Delineators" dated June 1971 describes test methods, test results, and includes proposed specifications. The current study includes 1) new products, their performance, and vehicular impact resistance; and 2) long term durability tests. 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 (Test Series 1) and April 29, 1977, (Test Series 2) 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 (Test Series 3), in Carson City, Nevada. This test series was witnessed by Caltrans personnel. A confirming vehicle impact test series on this manufacturer's product was conducted by the Laboratory in December 1977 (Test Series 4) on a closed section of Interstate 5 south of Sacramento. Also reported is an accelerated weathering correlation study currently in progress to estimate service life.

A maximum of ten 55 mph vehicular impacts was planned for each flexible guide marker post to be tested. The testing procedure conformed to Section III.D.5 of the "Specification for Flexible Plastic Guide Marker and Clearance Marker Posts" dated January 1977 and generally consisted of tests on groups

of three identical guide marker posts installed per the manufacturer's recommendations. The individual groups of posts were installed about 20 feet apart in holes drilled through the paved asphalt concrete surface of the dynamic test site for Test Series 1 and 2. The posts were installed in a manner similar to Test Series 3 and 4 with the exception of one group of posts that was installed in holes drilled through an AC shoulder and the remainder installed in an earth shoulder. The test vehicle used in Test Series 1 and 2 was a 1970 Mercury Monterey sedan; a recent model Jeep pickup was used in Test Series 3; and a 1972 AMC Matador sedan was used in Test Series 4. All posts were impacted approximately at the center of the front bumper of the test vehicle. The ambient temperature at the time of the vehicular impact tests varied between 70°F and 80°F for Test Series 1, 2 and 3 and between 45°F and 55°F for Test Series 4.

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 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 and by still photography on file at the Transportation Laboratory.

As the major objective of this study was to determine the vehicular impact resistance of the various posts tested, the question of impact resistance of the reflective material to be used with the posts was not specifically addressed in this study. Some posts were furnished with reflective material proposed by the suppliers; others were not reflectorized. The ability of the reflective material as furnished with some of the posts to withstand impact is discussed to some degree within the body of this report.

An accelerated weathering test is currently being conducted on samples of the plastic material from each marker post utilizing the Carbon-arc Fadeometer. These Laboratory test results will be correlated with 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 of the weather service life of each guide marker post and ultimately, after correlation 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 marker 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 non-driveable guide marker posts can further be divided into two groups, one group requiring and one not requiring backfilling in the interior as well as around the outside of the post. The Autopost, the Guardian, and the Lanco are the non-driveable type posts which do not require interior backfilling. The Syroflex and the Polypost, according to their manufacturer's recommendations, both require interior backfilling as well as backfilling around the outside of the post up to the ground line.

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. This claim was based on driving a jack-hammer type spade into the road shoulder to make a pilot hole, inserting the post into the resulting hole, and tamping to complete the installation. This method was not investigated during this study.

III. SUMMARY OF OBSERVATIONS (See Table on Page 8)

A. Non-driveable Guide Marker Posts

The following guide marker posts were found to be capable of withstanding 10 vehicular impacts at speeds of 55 mph and returning to a vertical position when tested in relatively mild temperatures of 70 to 80°F: 1) Autopost including the triangular with rounded corners, round, and cloverleaf cross sections; 2) Syroflex, and 3) Polypost. There was little or no significant damage to any of these posts nor to the impacting vehicle.

When tested under the same conditions as above, the Lanco T-section guide marker post developed an objectionable "S" shaped curve when viewed normal to the direction of impact. After 10 impacts the post approached a canted position of about 30° from the vertical.

The Guardian guide marker post is constructed with two sections that are riveted together. During the first impact at 55 mph, these sections separated. The front section of the post shattered on recurring vehicular impacts.

B. Carsonite Driveable Guide Marker Posts

Three different designs of the Carsonite drivable guide marker post were evaluated in this study. These were the 2 1/2-inch wide T-section post, the 2 1/2-inch wide ribbed post, and the 3 3/4-inch wide ribbed post. Although the 2 1/2-inch wide posts do not comply with Caltrans requirements for width of flexible delineators, these were prototype designs and were tested to determine the potential of the basic design concept.

The 2 1/2-inch wide T-section guide marker post was capable of withstanding a number of vehicular impacts at speeds up to 35 mph and return to a vertical position at the conclusion of the test. However, the web of this post sheared from the flange during the first impact. This resulted in an overly flexible post incapable of withstanding wind gusts without objectionable flexing.

The 2 1/2-inch wide ribbed post failed at an initial impact speed of 55 mph. However, subsequent tests with an initial impact speed of 35 mph followed by additional impacts at 55 mph resulted in a satisfactory performance. The damage to the tops of the posts became significant when the number of vehicular impacts on a given post was between 5 and 10.

The lower speed impact reported above resulted in the formation of a plastic hinge at the base of the post which increased the flexibility of the post. Thus with the introduction of the plastic hinge the post was able to withstand further higher speed impacts without failure. This phenomenon is manifested by both of the Carsonite ribbed post designs.

The behavior of the 3 3/4-inch wide ribbed post was similar to that of the 2 1/2-inch wide ribbed post when initially impacted at 35 mph followed by additional impacts at 55 mph.

As the 3 3/4-inch wide ribbed post is more flexible than the 2 1/2-inch wide ribbed post due to its cross sectional geometry and improved materials compounding, its performance would be expected to be more dependable. A later series of tests on this post tended to verify this conjecture as the post was able to withstand a number of impacts at 55 mph with the initial impact also at 55 mph. Nonetheless the post still tends to develop significant delamination at the top and in the area of the plastic hinge when the number of vehicular impacts at speeds of 55 mph is in excess of 5.

When impacted at speeds of 55 mph and a skew angle of 25°, the 3 3/4-inch wide ribbed post withstood 10 impacts with no delamination in the plastic hinge region and but little delamination of the top. This finding is considered significant as the normal impact in operation would be at a skew angle rather than headon into the post.

The 3 3/4-inch wide ribbed post is capable of being hit repeatedly - in excess of 10 times - at 35 mph with very little damage to the post. This may be considered a more typical impact condition in actual operation.

Due to the confinement and rigidity created by an asphalt concrete pavement, the Carsonite guide marker post performs poorly under impact conditions when installed in an AC surface. Failure of the posts occurred when subjected to repeated impacts of 4 or less at 55 mph.

It is significant to note that in the extensive testing program on the Carsonite guide marker post there was little or no damage to the test vehicle after about 170 individual impacts with the posts with the majority of impacts at speeds of 55 mph.

C. Installation

The amount of work and time required to install the various flexible guide marker posts varied considerably and in relation to their design. The driveable Carsonite post requires considerable less effort and time to install than the non-driveable posts.

The Carsonite post can be easily and rapidly installed with a hand driver into a soil foundation. However, it cannot be driven through an AC surface nor through a compacted rock base.

Installation of all the non-driveable posts is similar except some designs require an interior backfill. Thus the need for an interior backfill increases the installation time accordingly.

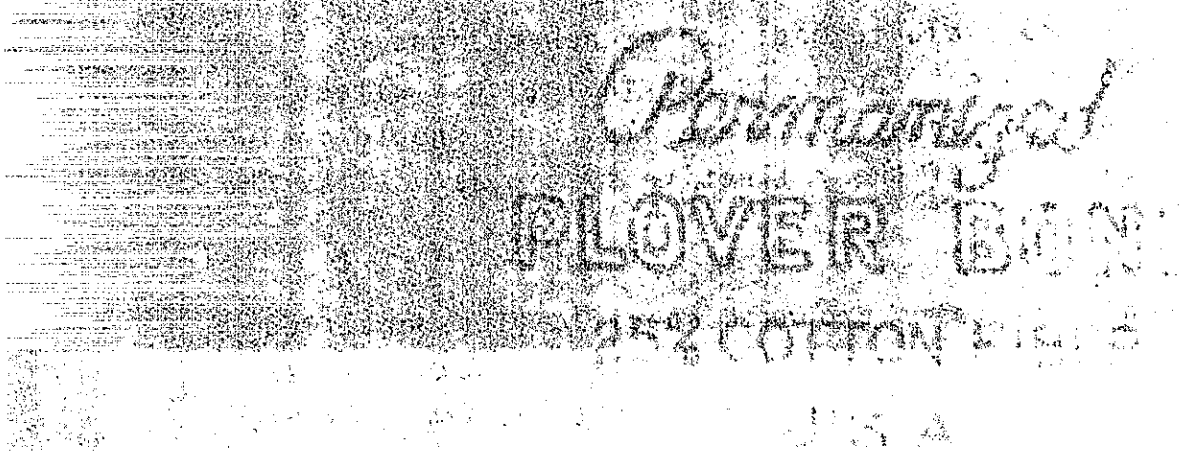
IV. RECOMMENDATIONS

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. The program to evaluate modified or new designs of flexible guide marker posts which appear to be viable, cost effective alternates should continue. Future evaluations should include the impact resistance of the reflective system as well as the post.

3. The Appendix contains proposed specifications entitled "Specifications For Driveable Flexible Plastic Guide Marker and Clearance Marker Posts" and "Specifications For Flexible Plastic Guide Marker and Clearance Marker Posts." It is recommended that these specifications be included in future purchase orders for flexible guide marker and clearance marker posts.

4. For detailed recommendations concerning each tested post, see Test Results and Discussion.



Summary of Guide Marker Post Impact Performance

Post Identification	Number of Impacts to Failure of Post	Post Impact Serviceability Limit - # of Hits	Speed mph	Angle of Impact - degrees	% Loss of Reflector	Remarks
Autopost						
Round	> 10	≥ 10	55	0	variable -	Group of 3 tested -
Triangular	> 10	≥ 10	55	0	100% to	Reflective material
Cloverleaf	> 10	≥ 10	55	0	small amount	(Reflexite) intact on one of three
Lanco T Post	> 10	< 5	55	0	Not Tested	Developed S Shaped curve
Syroflex (Flexpost)	> 10	≥ 10	55	0	Not Tested	
Polypost	> 10	≥ 10	55	0	Not Tested	
Guardian	1	1	55	0	Not Tested	Post delaminated after 1st hit.
Carsonite T	10	≤ 5	35	0	Not Tested	Web separation after 1st hit.
Carsonite 2 1/2" Ribbed	1	1	55	0	0	
" " " " "	10	≤ 5	35 & 55	0	50%/5 hits	
Carsonite 3 3/4" Ribbed	10	≤ 5	55	0	30%/5 hits	Post hinged prior to impact
" " " "	5 or less	1	55			" " "
						Installed in AC Pavement
" " " "	10	>5 < 10	55	45	75%/10 hits	Post hinged prior to impact
" " " "	≥ 10	10	55	25	15	" " " "
" " " "	≥ 10	≥ 10	35	0	10 - 30	" " " "
" " " "	10	≤ 5	45	0	10	" " " "
						High Intensity Reflective Sheeting

V. TEST RESULTS AND DISCUSSION

A. The Autopost Guide Marker Posts

The triangular cross section Autopost guide marker post had been tested previously and found to be satisfactory for vehicular impact resistance provided the interior was backfilled to groundline. 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. Design details and photographs of the cloverleaf post are shown in Figures 1 and 2; those for the circular post are shown in Figures 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 digging or drilling a hole with subsequent backfilling and tamping 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.

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

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 2 and 4 show the amount of pullout as the distance the black line has been raised above the ground level.

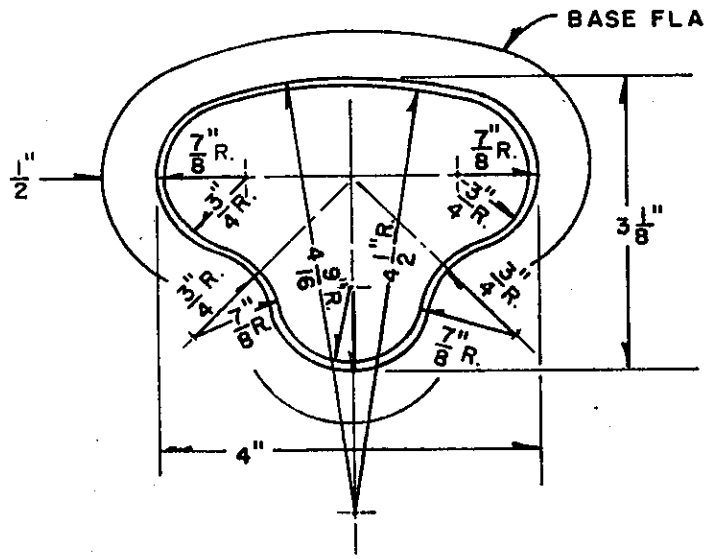
No vehicular damage was detected after striking these guide markers at 55 mph. The damage to the three posts tested for each shape was considered minimal.

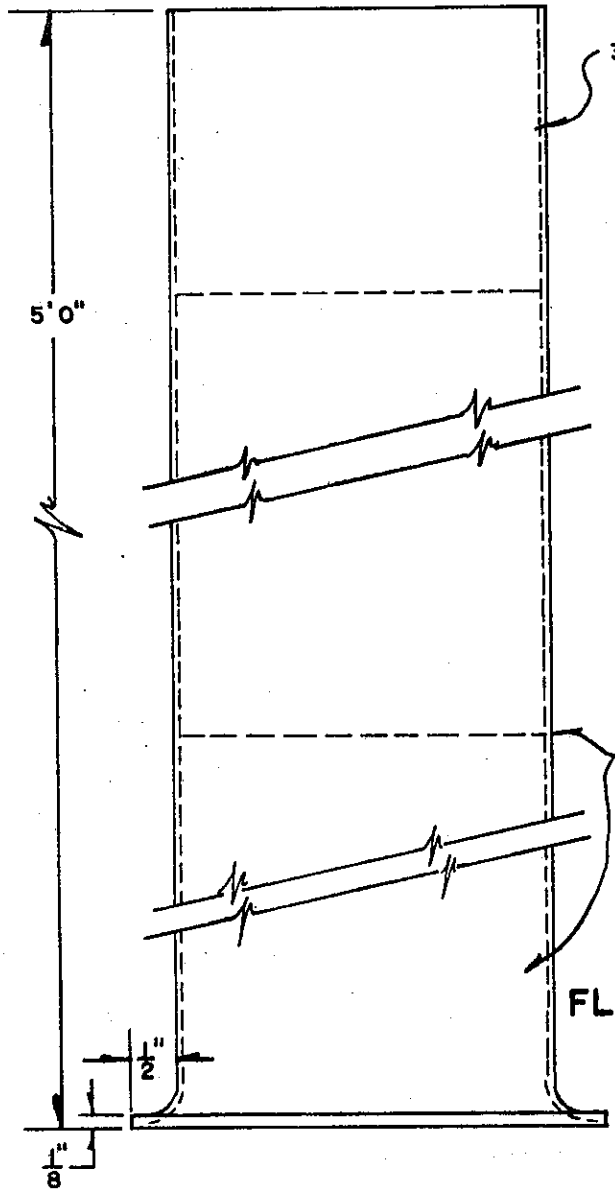
The photo in the upper left corner of each of Figures 2 and 4 shows one post before the first impact and the other three photos on the page show all three posts after 10 vehicular impacts. The reflective sheeting (Reflexite) on the post is damaged from the vehicular impacts and allowances must be made 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 disclosed with the passage of time. In addition to in-service installations, some samples of the Autopost have been placed on the roof of the Structural Materials Laboratory for weathering and other 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 change in tensile strength and elongation attributable to weathering and ultra-violet light exposure and also note any change in appearance.

Even though our second 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. It is recommended that the Autopost be considered acceptable on an interim basis. They are capable of complying with the requirements of the present specification for non-drivable flexible plastic guide markers.

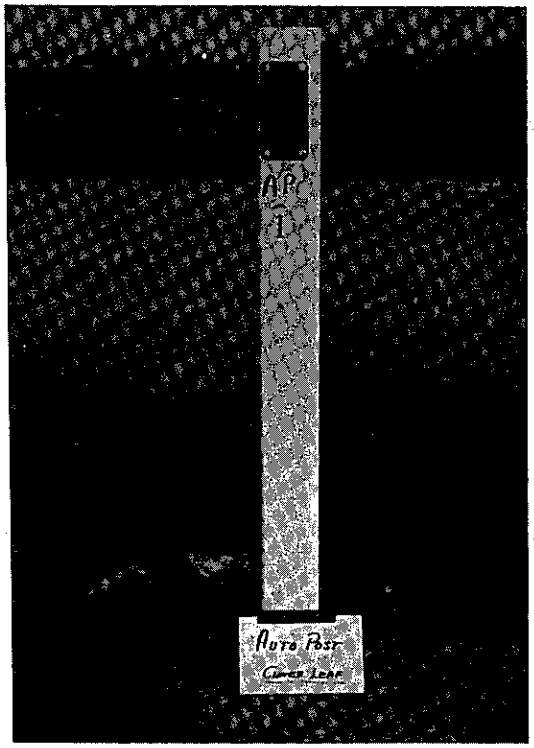




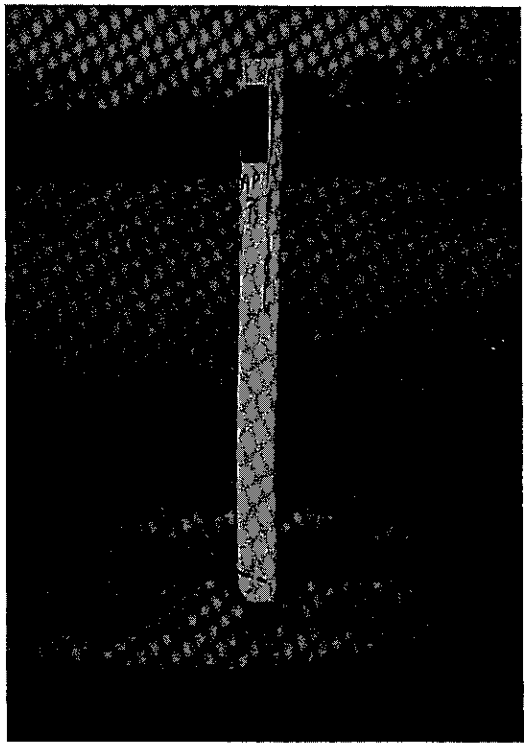
AUTO POST "CLOVERLEAF"

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

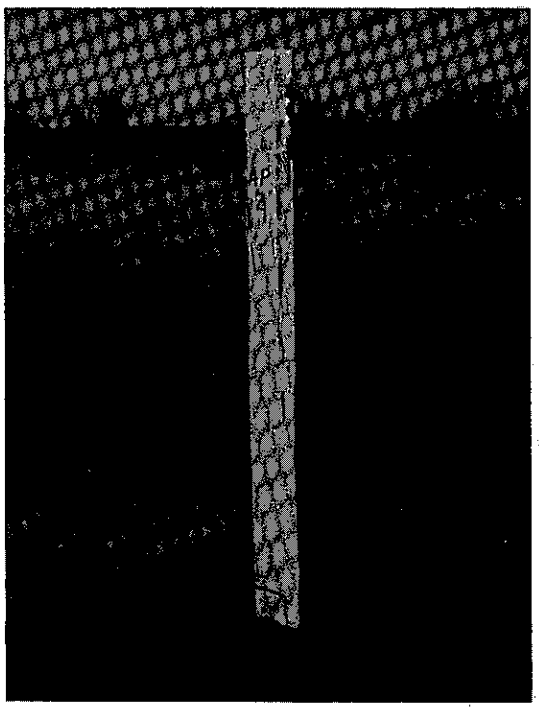
AUTOPOST - CLOVERLEAF MODEL Figure 2



Before Impact



After 10 Impacts



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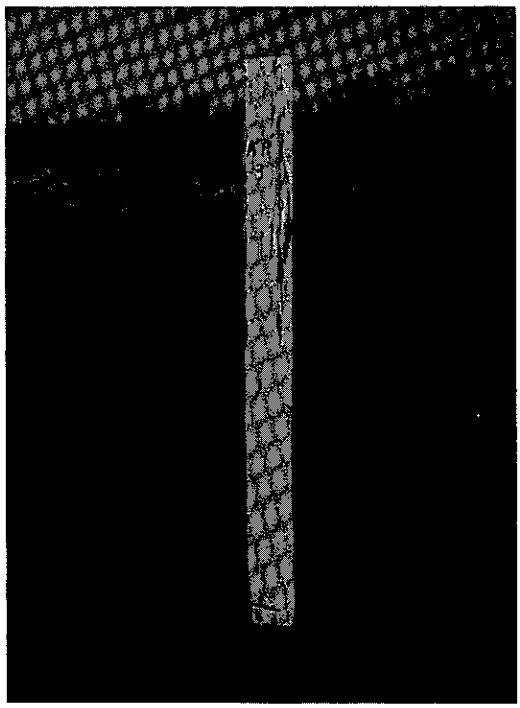

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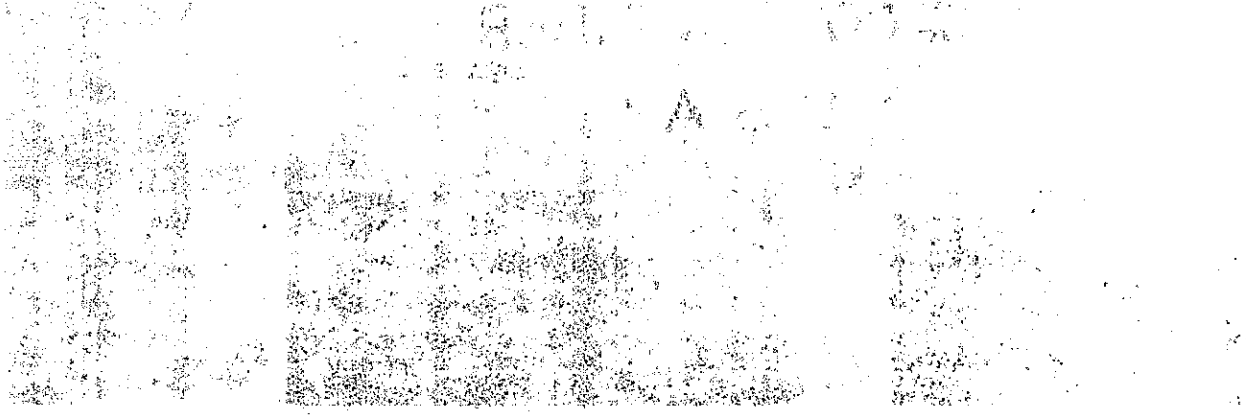


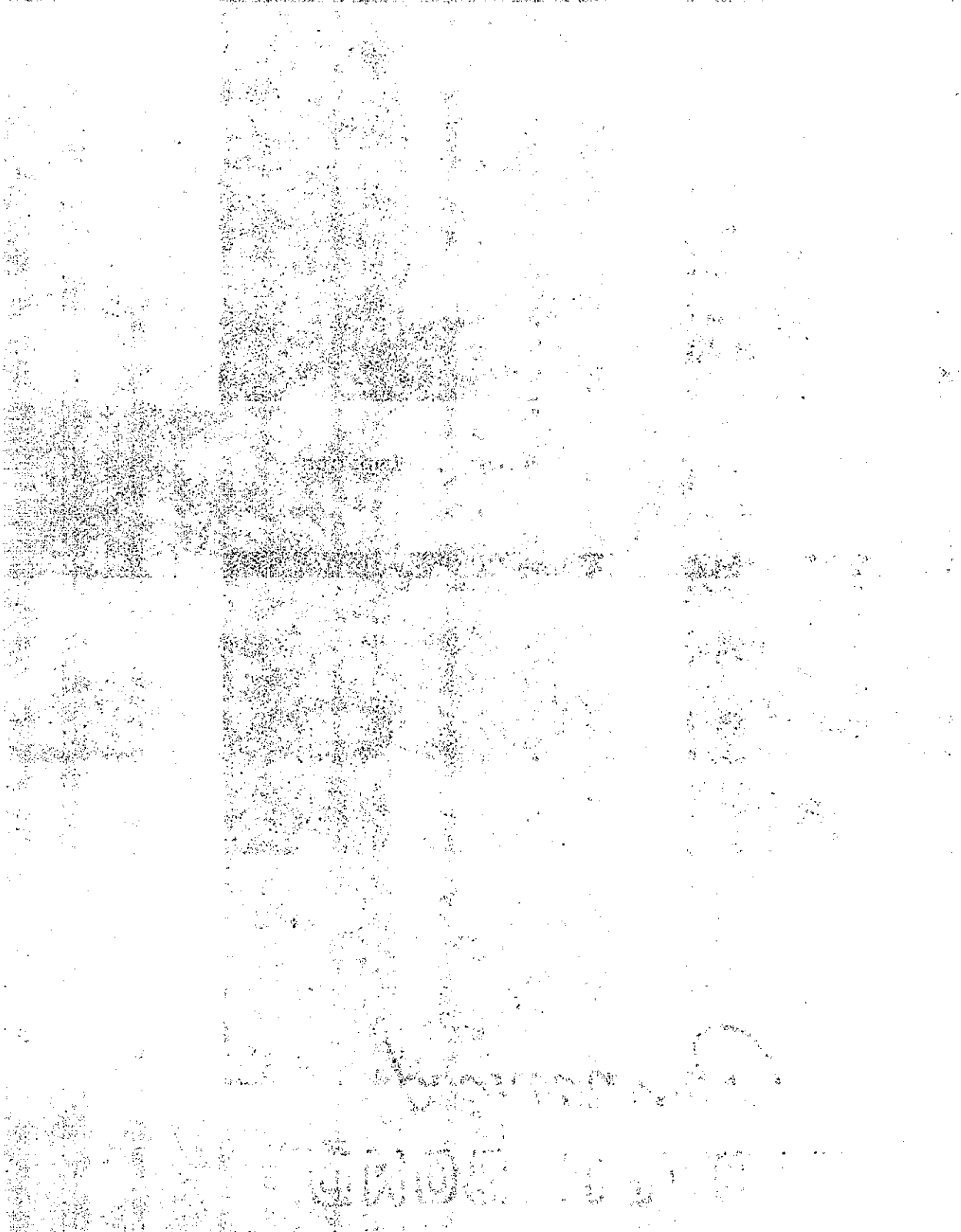
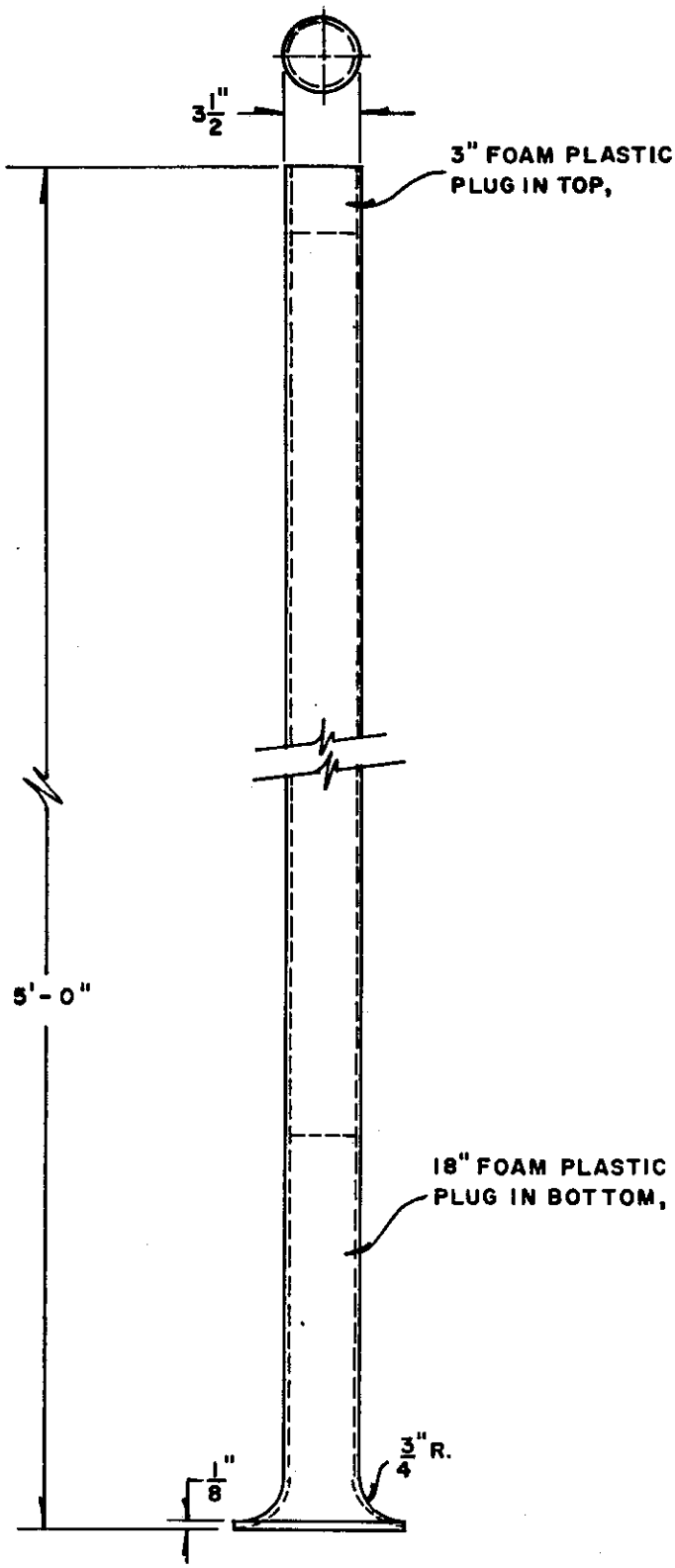


Figure 3

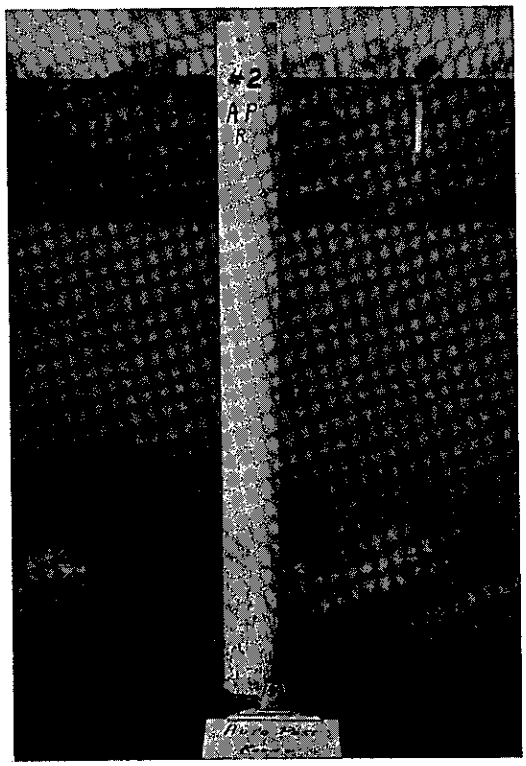


AUTOPOST, CIRCULAR

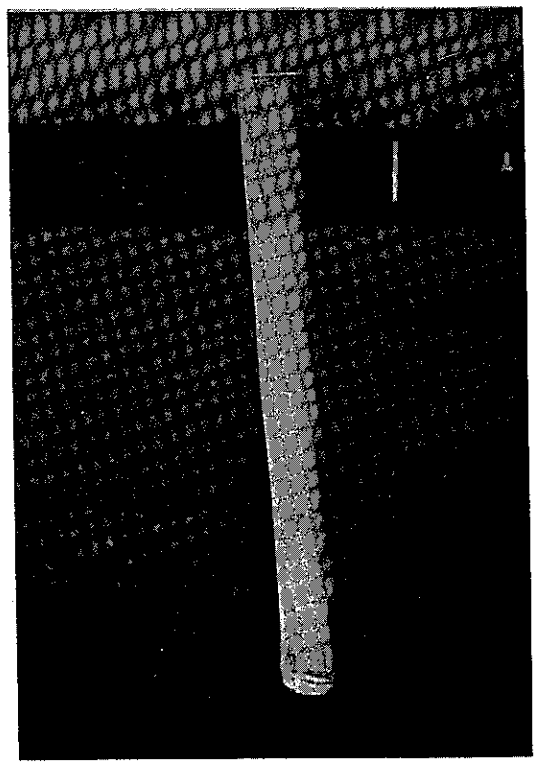
FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

AUTOPOST - CIRCULAR MODEL

Figure 4



Before Impact



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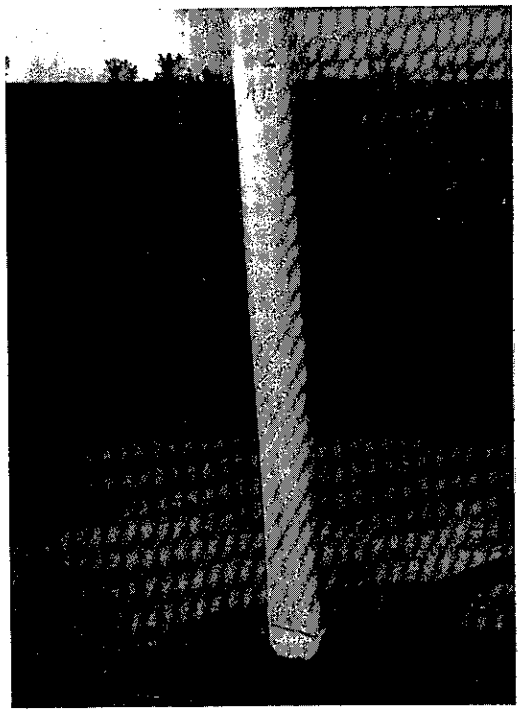

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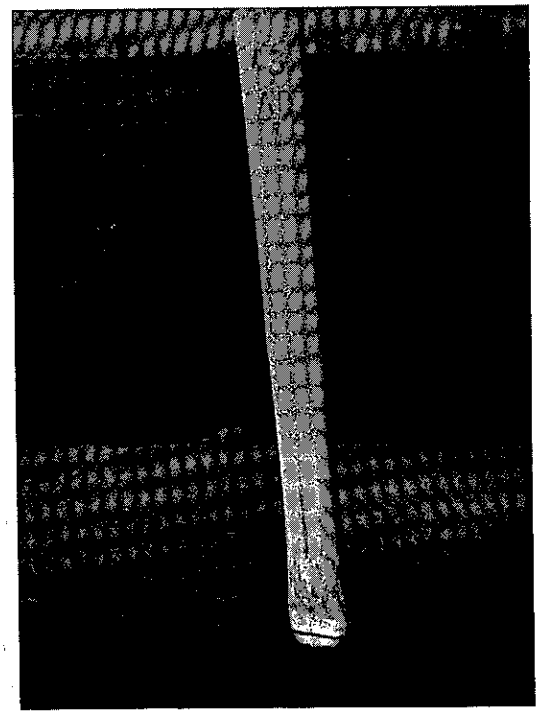


After 10 Impacts

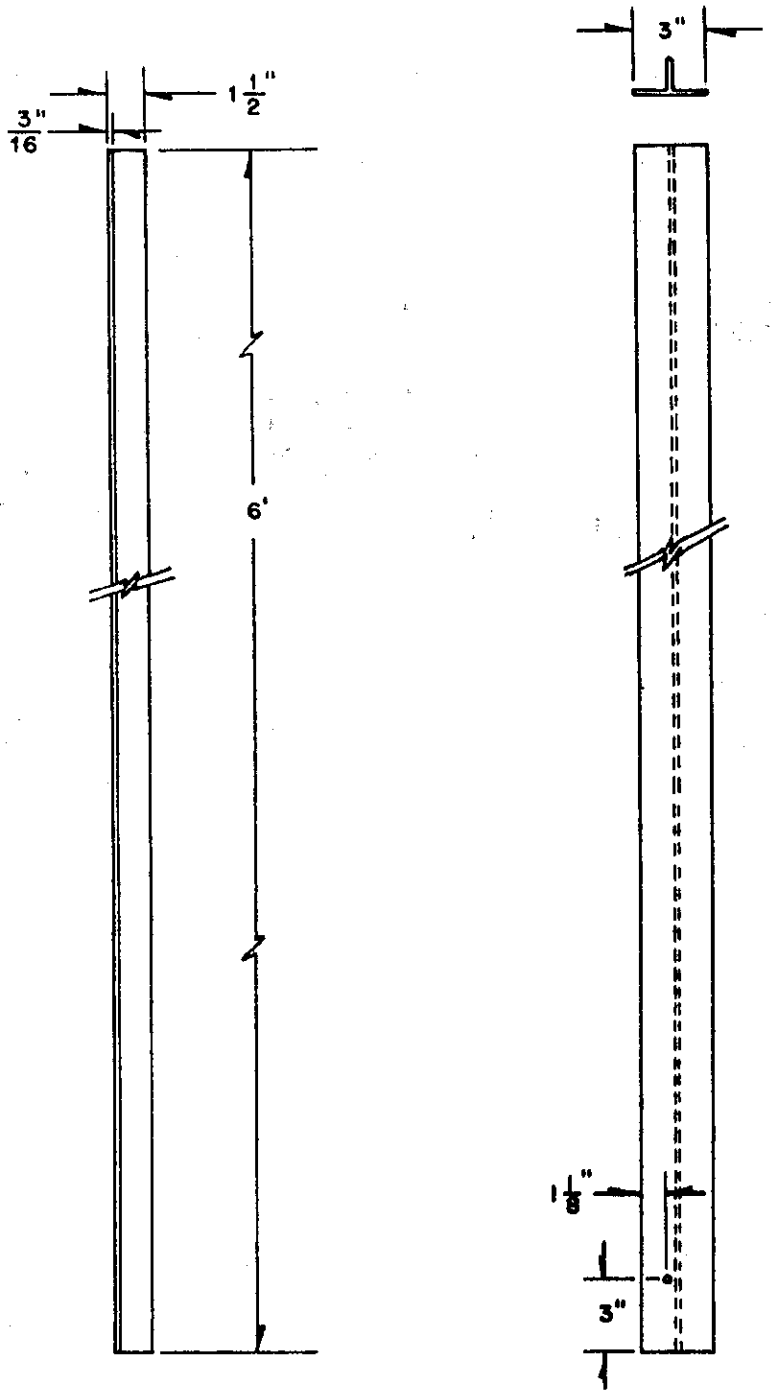
B. Lanco T-Section Guide Marker Post

Lanco had previously submitted and Caltrans had tested and approved a flexible guide marker post designated as their LDP-6 post. However, this post differs greatly from the new T-section guide marker post we tested on February 14, 1977. This new Lanco T-section marker post, identified as their LDP-8 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 markers 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.

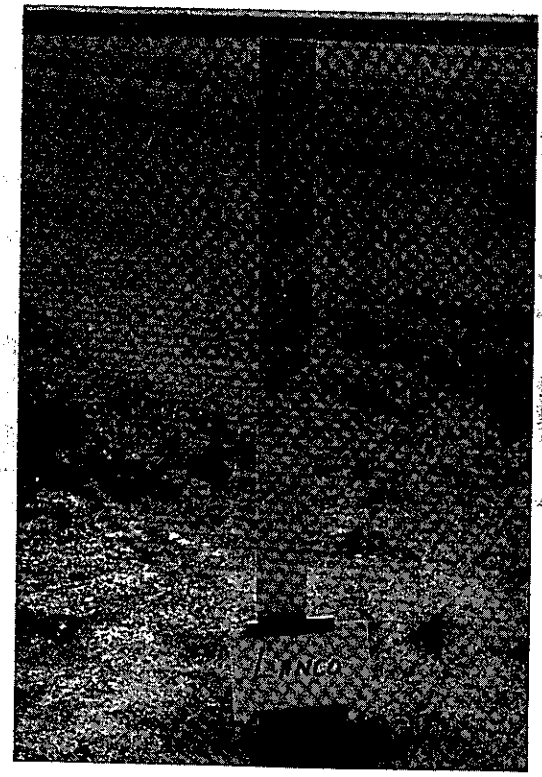
It is recommended that no further testing be performed with the LDP-8 Lanco T-post design as a flexible guide marker post. Its performance does not compare with the other flexible guide marker posts being evaluated.



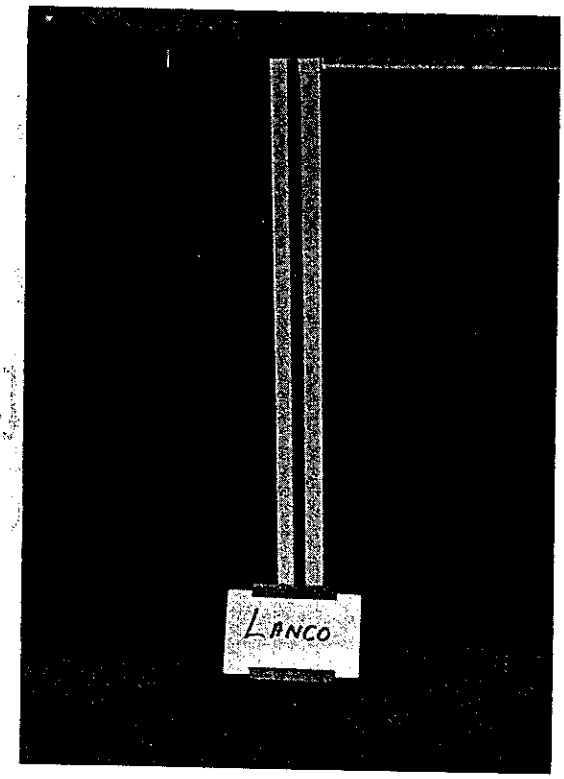
LANCO LDP-8 "TEE"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

LANCO T-POST
(Model LDP-8)

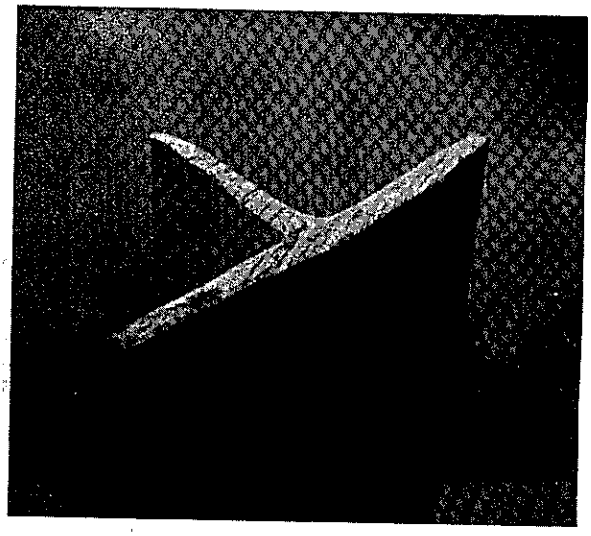
Figure 6



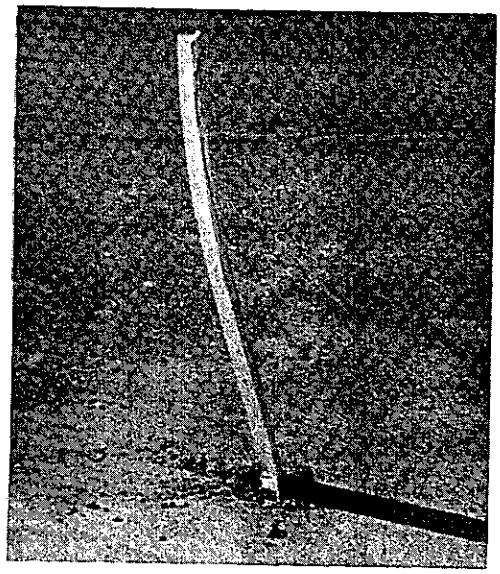
Front View



Back View



Top View



Side View of Post
After 10 Impacts

C. Syroflex Guide Marker Post (Flexopost)

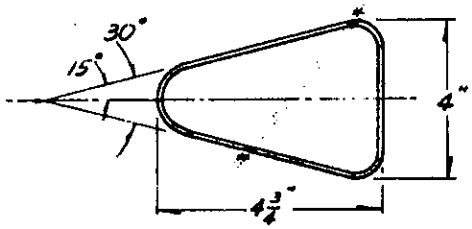
On February 14, 1977, the Syroflex guide marker post was tested with 10 vehicular impacts. This guide marker post had previously been tested and approved by Caltrans and there are many installations throughout the state. It is fabricated from a flexible white plastic and has an isosceles triangle cross section. The long sides of the isosceles triangle are approximately 4 3/4" and the short side 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.

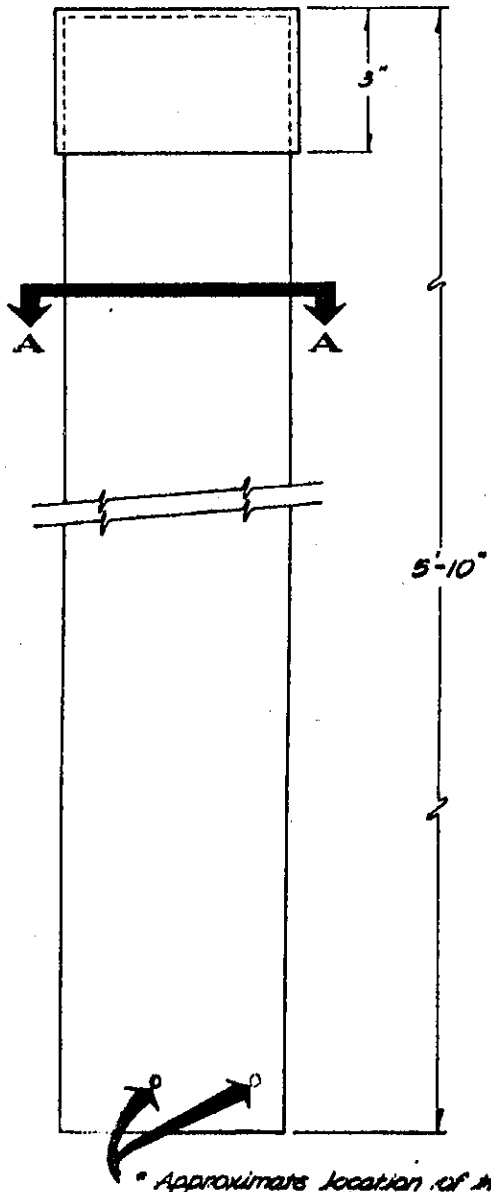
This guide marker post was able to withstand the 10 vehicular impacts at 55 mph and satisfactorily return to a vertical position, as was found in earlier tests and evaluations. The black cap cover on the top of the post was knocked off on the first vehicular impact. The upper left photo in Figure 8 shows one of the three posts 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

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 the long term serviceability of this marker as currently formulated 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 deferred until suitable evidence is developed or obtained which would attest to its long term serviceability.





* Approximate location of two holes to take ⅜" diam. by 12" long iron anchor rod.

Material:

Post: Seamless, white polyethylene extrusion with $\frac{5}{32}$" thick walls.

Cap: Slip-lock secured black polyethylene.

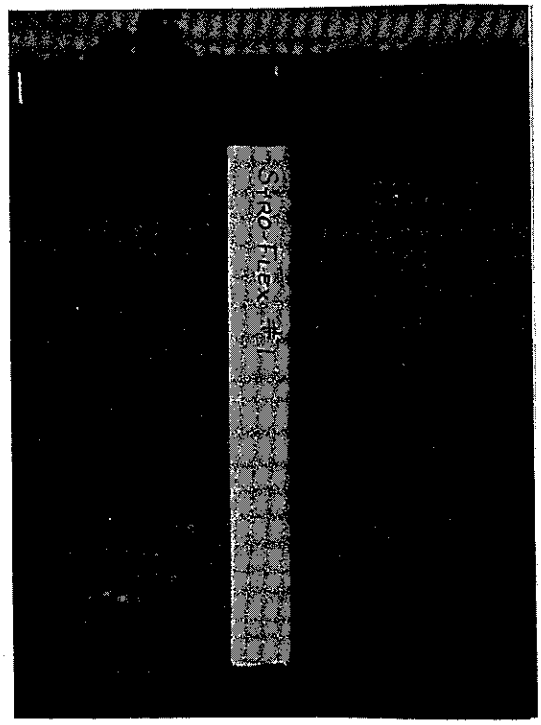
SYROFLEX
FLEXOPOST

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

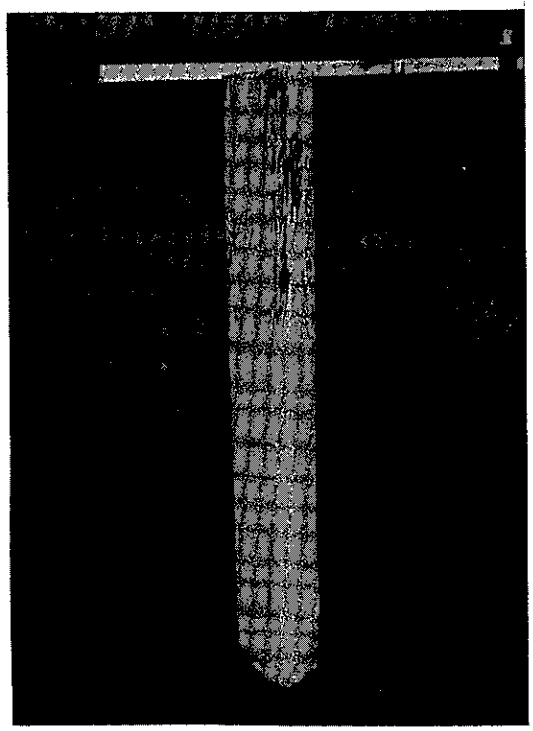
FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

SYROFLEX POST

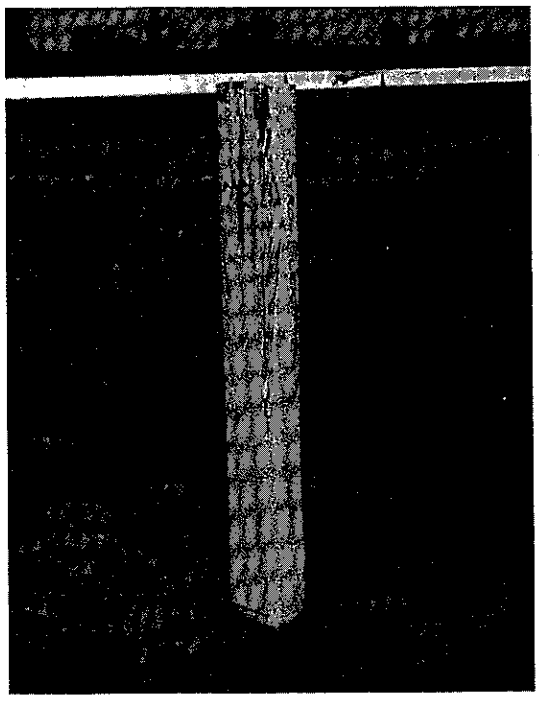
Figure 8



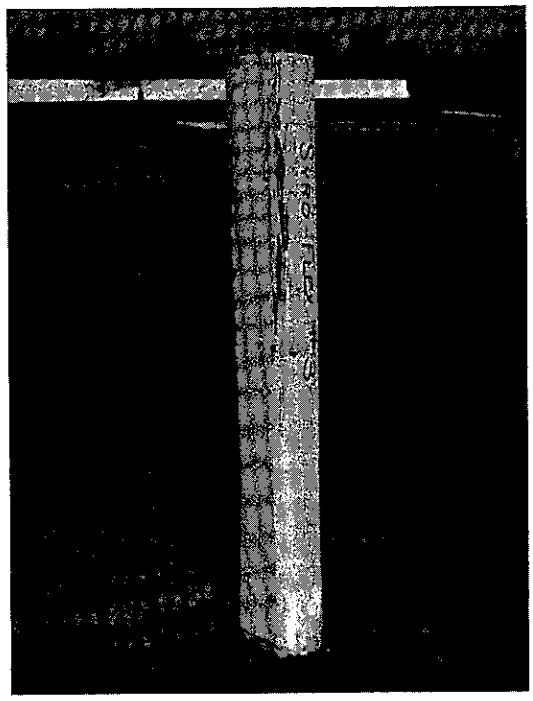
Before Impact



After 10 Impacts



After 10 Impacts



After 10 Impacts

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.

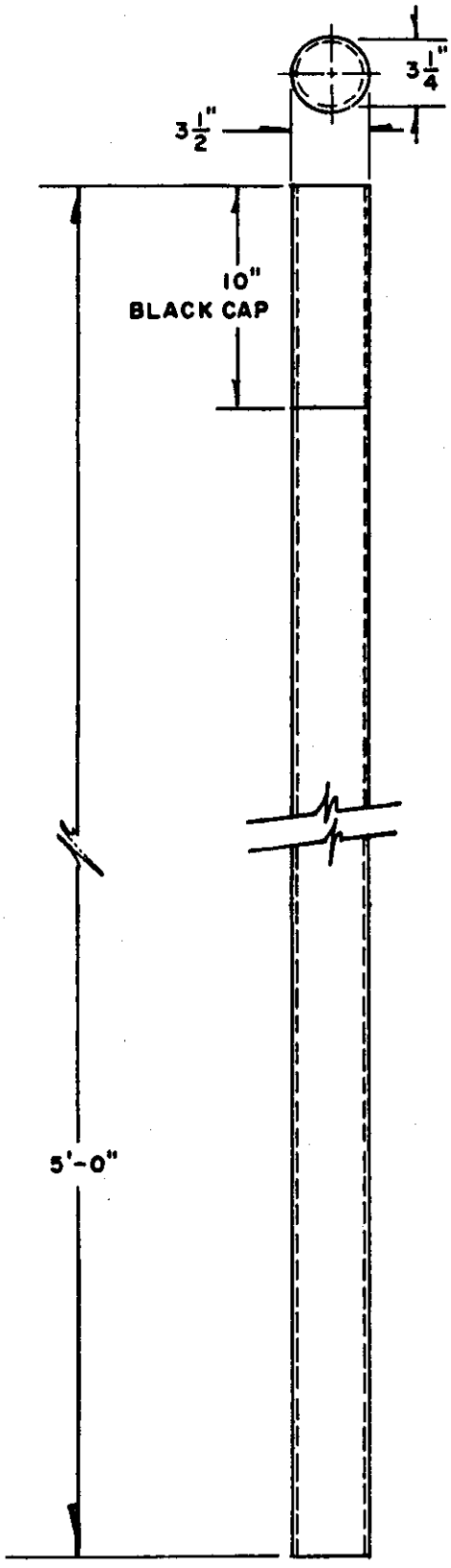
This post is fabricated out of white flexible plastic with a 10" long black flexible plastic top. It is circular in cross section with a 3 1/2" diameter. Details of the Polypost are shown in Figure 9. This hollow post is a non-driveable type which requires a hole in the ground and backfilling both inside and out up 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 was backfilled.

There was slight or no damage to the vehicle from the 55 mph impact with 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 that the backfill for this post is tightly compacted as anchorage depends entirely on 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.

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.

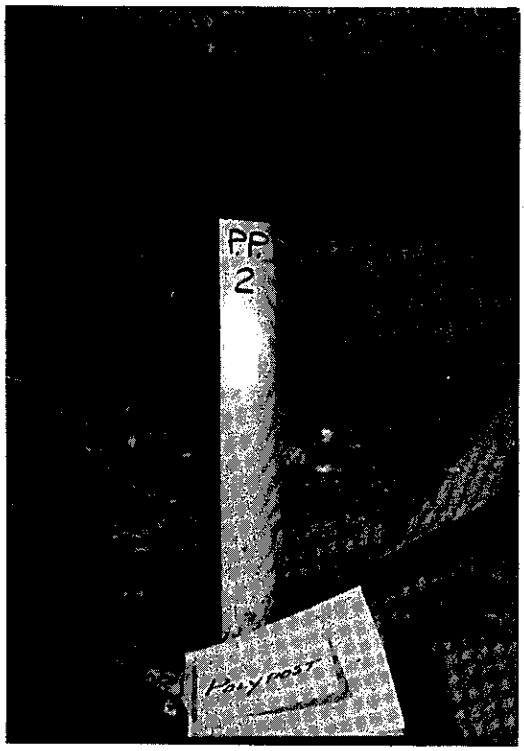
Samples of this guide marker post have been placed on the roof of the Transportation Laboratory to evaluate its durability in outdoor weather and exposed sunlight. Also, samples have been placed in the fadeometer and subjected to an accelerated exposure of ultraviolet light. These exposed specimens will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

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

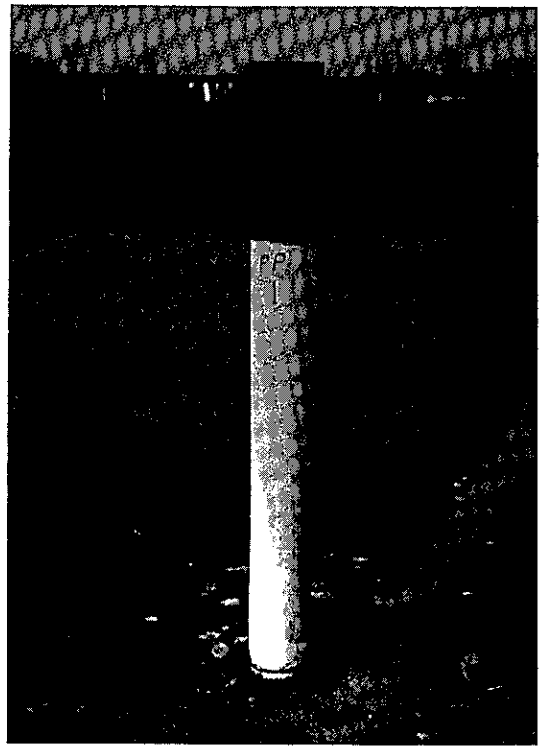


POLYPOST

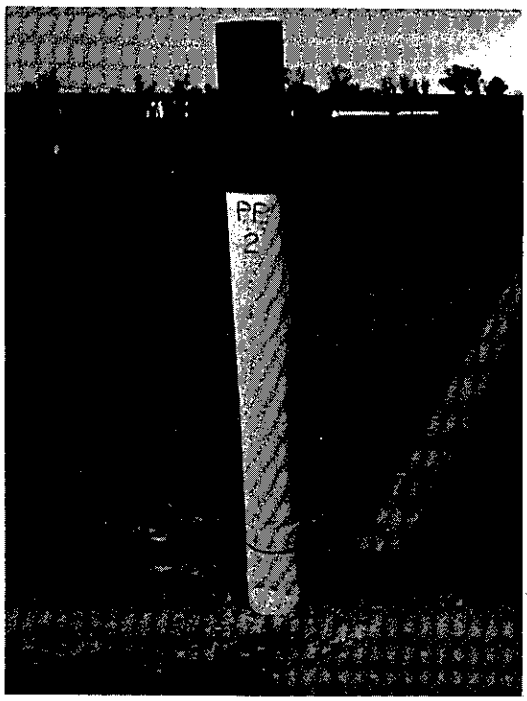
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST



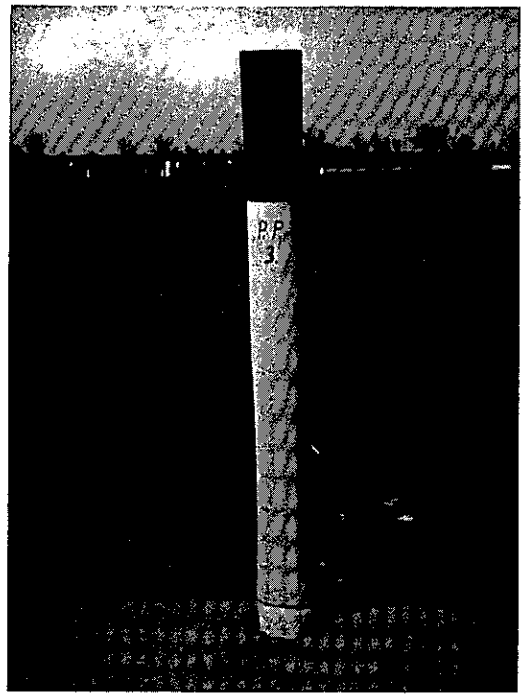
Before Impact



After 10 Impacts



After 10 Impacts



After 10 Impacts

PLOVER BOND
25% COTTON FIBER
U.S.A

E. Guardian Guide Marker Post

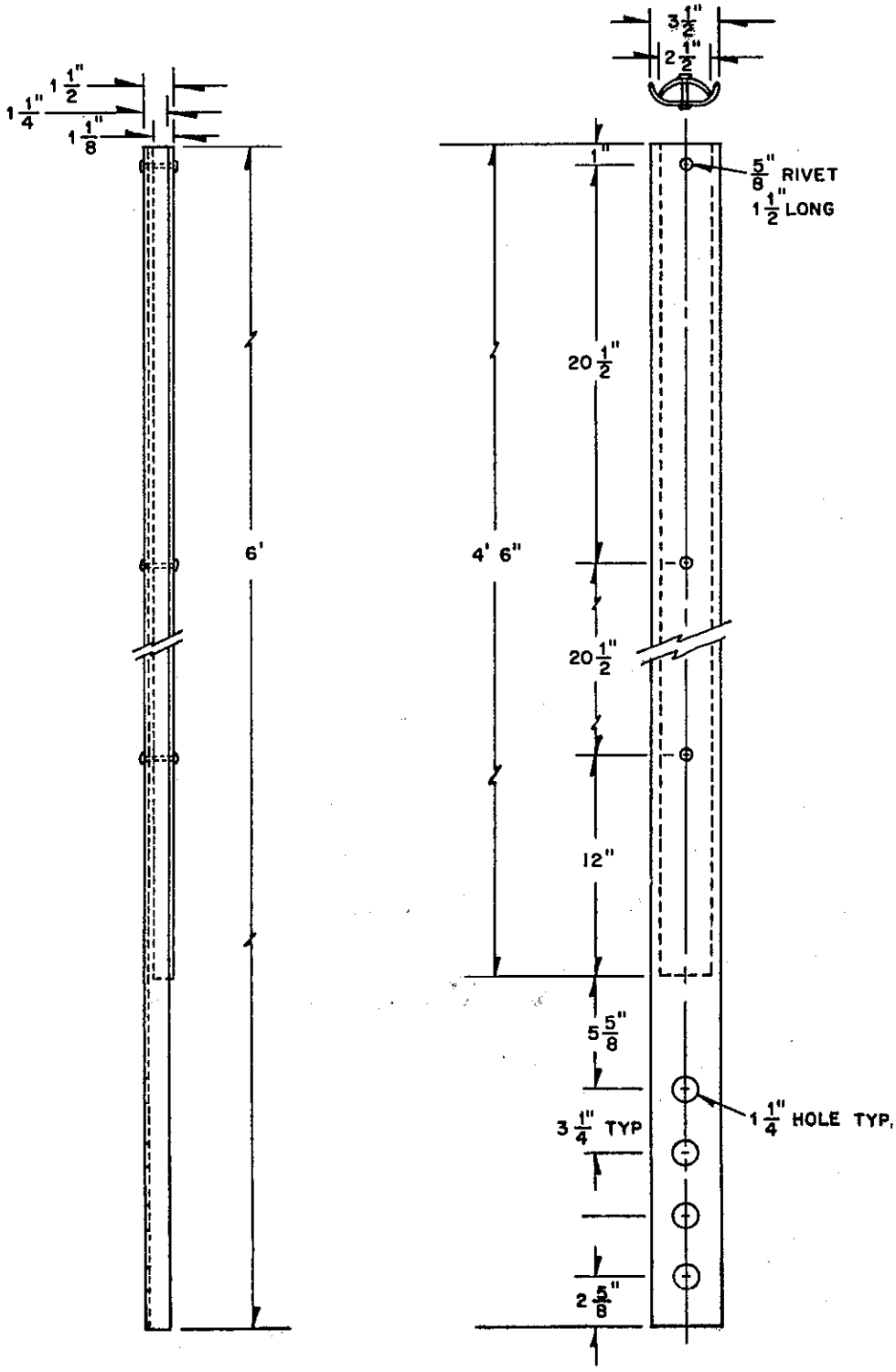
The Guardian flexible guide marker post was tested on April 29, 1977, for its ability to withstand repeated vehicular impacts at 55 mph. This post is fabricated of a relatively hard but flexible polycarbonate plastic. The manufacturer claims that ultraviolet light inhibitors have been incorporated into the plastic which assures little or no effect 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 of 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. To consider the post semi-driveable a special spade or tool would be required to make a pilot hole in the ground. The post would then be inserted into the pilot hole and the surrounding soil tamped to provide a firm installation. 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.

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

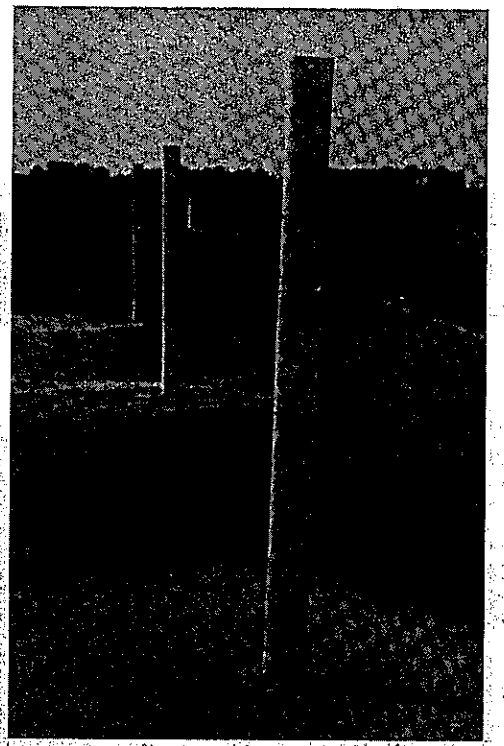
Figure 11



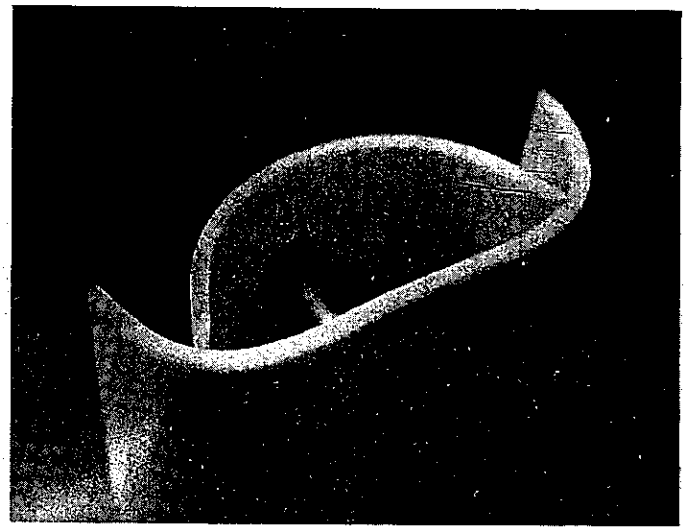
"GUARDIAN"

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

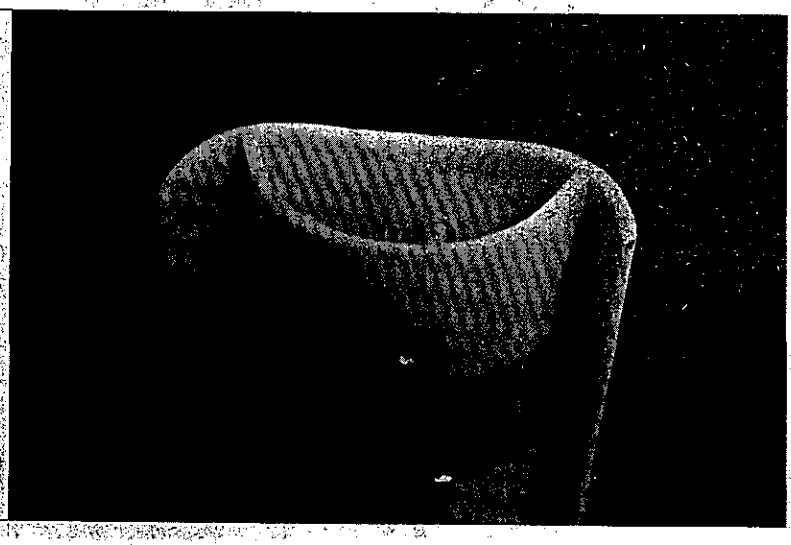
GUARDIAN MARKER POST Figure 12



Front View Before Impact



Top - Front View



Top - Back View

F. Carsonite Guide Marker Posts

Carsonite flexible guide marker posts were tested on February 14, 1977, and again on April 29, 1977, both tests being conducted on the paved surface of the Translab dynamic test site at the Highway Patrol Academy. They were tested again on May 25, 1977, outside of Carson City by the manufacturer on the earth shoulder of a county road. This test was witnessed by Laboratory and the Office of Traffic personnel. An additional series of impact tests was conducted by the Transportation Laboratory on the shoulder of an unopened section of Interstate 5 near Sacramento in December 1977. This test series was conducted to confirm and complement the tests run by the manufacturer. The posts for this last test series were representative of the manufacturer's latest production.

The Carsonite flexible delineator is truly a driveable system for installations in a soil foundation. It can easily be installed by methods similar to those employed to install the steel post used for guide marker posts. This post, however, cannot be driven through an asphalt concrete surface nor an aggregate base. It is anticipated that difficulty would also be experienced in driving the post in a rocky subgrade. 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. The resulting post is flexible, but rigid enough to allow it to be driven in place.

Since its inception and throughout these test series, several major modifications have been made to the marker. The latest design was the one tested in the third test series, which was conducted by the manufacturer, and in the fourth test series conducted on Interstate 5. For the first test series on February 14, 1977 by the Transportation Laboratory, there

were two designs. The first 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 and Figure 14 shows photos. 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 15 shows the details and Figure 16 shows photographs of this 2 1/2" wide ribbed post.

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 design evaluated in this study. It is detailed in Figure 18 and pictured in photos in Figure 19.

The 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. The fourth and final test series conducted by the Transportation Laboratory in December 1977 were on posts fabricated to this same shape and formulation.

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 separated or

split from the flange or face as shown in Figure 14. 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 return to 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 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, and return to an upright position immediately following impact. The posts withstood about 5 impacts without showing any significant damage. During the next 5 impacts, however, the top of the posts began to delaminate and fray with this damage progressing upon each additional impact. Delamination of the posts also occurred in the region of the plastic hinge with the magnitude of delamination increasing with each impact. After a total of ten hits, the tops of all posts impacted were severely delaminated and ragged in appearance.

The 3 3/4" wide ribbed post was tested in the Laboratory's 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. As in the tests on the 2 1/2-inch wide ribbed post, the tops of these posts also started to show significant damage after about 5 impacts with the damage progressing perceptibly during the next 5 impacts. The fraying of the post tops after 10 impacts was about the same as noted for the 2 1/2-inch wide post. Delamination also occurred in the region of the plastic hinge.

Both the 2 1/2-inch and the 3 3/4-inch wide ribbed posts developed a plastic hinge toward the base of the post in the vicinity of the groundline after the first 35 mph impact. This phenonemon increased the flexibility of the posts and rendered them more impact resistant. The plastic hinge did not affect the post's ability to return to an upright and vertical position following an impact.

The third test series was conducted by the manufacturer in Carson City on the 3 3/4" wide ribbed post which was fabricated with the improved formulation mentioned earlier. The geometry of the post cross section was the same as the 3 3/4" posts tested in the second test series. The posts were readily installed by hand driving methods into the earth shoulder of a county road. The posts were impacted by a Jeep pickup initially at 35 mph followed by nine more impacts at 55 mph. The performance of these posts was very similar to those impacted in the second test series with little damage occurring to the posts during the first 5 impacts, but with progressive damage occuring to the tops of the posts during the next 5 impacts. Figure 19A shows the typical damage to the top of the posts that occurred after 10 impacts. Figure 19B shows the imprint of a post as it was slapped to the ground by the impact. This slapping action in addition to the impact of the vehicle explains the damage that occurs to the top of the posts.

The manufacturer also demonstrated comparable ease in driving the post as shown in the photo in Figure 19C. This demonstration consisted of driving both a steel post and the Carsonite post. The Carsonite post was as easily driven as the steel post at this particular location.

A fourth series of impact tests on the 3 3/4" wide Carsonite flexible delineator post was conducted by the Transportation Laboratory in December 1977 on representative posts taken from a current production lot. This test series was performed on a group of posts installed in the median shoulder of a new, unopened section of Interstate 5 near Sacramento. The purpose of this test series was to corroborate the results of previous tests, but on posts installed under typical California highway conditions and on posts taken from a typical production lot. All posts were 5 feet long, and were driven with the manufacturer's tube type, hand drive hammer to a depth of 16 inches with the remaining 44 inches of the post exposed above the ground. All posts also were reflectorized, some with 3M Engineering Grade reflective sheeting 3" by 12" in size and the remainder with 3M High Intensity reflective sheeting 3" by 4" in size. The test vehicle used throughout this series was a 1972 AMC Matador sedan which was in good condition. All posts were impacted approximately at the center of the front bumper. The ambient air temperature during this test series was in the high 40's and low 50's.

Seven different tests were performed. A brief description of the various tests and the test results are as follows:

Test No. 1 consisted of three posts driven about 20 feet apart in the median, about 5 feet off the edge of the paved shoulder. The posts were easily driveable at this unpaved location as the

soil was native sandy clay that had been shaped and compacted and was free of large rocks or other interfering objects. The test consisted of 10 head-on impacts at 55 mph. All three posts were impacted concurrently. The posts in this test were not flexed to develop a plastic hinge near ground level prior to the first vehicle impact. (Flexing consists of bending the top of the installed post down to the ground in the same direction it would be deflected when impacted.) After the first impact all three posts developed a hinge approximately 4" to 6" above the ground line, but suffered very little damage and returned to their erect position. After five impacts some delamination or fiber separation had occurred at the hinges, but the posts continued to return to within 5 to 10 degrees of their erect position. At least 15 percent of the reflective sheeting faces were damaged but all three posts would still be considered serviceable. After 10 impacts the posts still returned to a raised position but were severely delaminated and somewhat splintered in the hinge region. The first post listed approximately 5 degrees from its erect position, the second post about 20 degrees, and the third post approximately 45 degrees. Because of the hinge area damage near ground level, all posts were very unstable and tended to "wave in the breeze". Damage to the reflective sheeting faces varied from 20 to 70 percent.

Test No. 2 consisted of three more posts driven in the median soil about 20 feet apart and about 5 feet from the edge of the paved shoulder. These posts were flexed by hand to induce plastic hinges near the base of the posts prior to the first vehicle impact. They were impacted 10 times head-on at 55 mph. After the first impact, a visible hinge developed in all posts approximately 3 1/2" to 4" from the ground line. The development of the hinge closer to the ground could be attributed to

the induced hinge. After 5 impacts, delamination had started to develop in the hinge areas but the posts continued to return to within 5 to 20 degrees of their erect postion. Although 15 to 45 percent of the reflective sheeting faces were damaged, all three posts were still considered serviceable. After 10 impacts, the posts continued to return to a raised position, but the hinge areas of the first and third posts were badly delaminated and shattered. The first post had a 25 degree list and the third post about a 40 degree list from their erect positions and both tended to "wave in the breeze". Oddly, the center post returned to its erect position and was quite stable. About 50 to 70 percent of the reflective sheeting faces were damaged. From the results of Tests Nos. 1 and 2, there appeared to be no significant difference between the amount of damage suffered by the posts after ten 55 mph impacts whether they were or were not flexed to induce a base hinge prior to the first impact.

Test No. 3 consisted of three posts installed 20 feet apart in the asphalt median shoulder approximately 2 feet from the edge of the PCC pavement. Since it was not possible to drive the posts through the 2-inch thick asphalt concrete pavement and the underlying 6 to 8 inches of crushed rock base, it was necessary to drill through them with a 4 1/4 inch diameter core bit. After the crushed rock was removed, the hole was filled and compacted with native sandy clay material in layers of 4". The 5-foot long Carsonite posts were then driven in the native material to provide a height of 44 inches above the median shoulder pavement. These posts were to be vehicle impacted 10 times head-on at 55 mph. After the first impact all posts self-erected and a hinge had developed approximately 4" above the ground. These posts were flexed prior to the first impact to induce the plastic hinge. On the second impact, post #1 pulled out ot the ground. Severe damage occurred to posts #2 and #3 in the base hinge region. On

the fourth impact, post #2 was broken and was not self-erecting - a failure. On impact No. 5, post #3 was bent over and pulled out of the ground. It was the consensus of the observers that this post is not satisfactory for installation in an AC pavement. This is also concurred in by the manufacturer. It is the recommendation of the manufacturer that his post not be installed in a paved shoulder. He proposes instead that a specially designed metal base be epoxied to the pavement and the post be mounted to the base with bolts or pins. If damaged, the post can readily be replaced. A design of this type has been installed on the "Q" Street offramp on Interstate 5 in Sacramento for operational evaluation.

It is somewhat difficult to understand why the Carsonite post performs so poorly when driven in a prepared foundation hole in AC pavement. However, from the visual observation of the damage, the inadequate performance is possibly caused by the post being firmly confined by the AC surface as if it were installed in a vise. Thus the radius of flexure is so short the post fails by a combination of direct shear and flexure as the plastic hinge action cannot develop.

Test No. 4 consisted of one post driven in the soil about 5 feet off the edge of the median shoulder pavement. The post was skewed at an angle of about 45 degrees to the direction of impact. This post was manually flexed and then vehicle impacted 10 times at 55 mph and angle of 45 degrees. After the first impact there was slight damage and the post was self-erecting. A hinge started to develop approximately 5 inches above the ground line. After five impacts the top of the post started to fray, but the post was self-erecting and looked good. After 10 impacts the top of the post was badly frayed and about 75 percent of the reflective sheeting face was damaged. The base of the post at the hinge was in good condition. No appreciable delamination or splintering had developed in the hinge region as had occurred in the head-on impacts in Tests No.s 1, 2, and 3.

Test No. 5 consisted of one post driven in the soil about 5 feet off the edge of the paved shoulder and skewed at an angle of about 25 degrees counterclockwise with respect to the direction of impact. The post was impacted 10 times at 55 mph and an angle of 25 degrees. The post was flexed prior to the first vehicle impact. After the first impact, there was no visible damage and the post was self-erecting. After five impacts there was slight separation or brooming at the top of the post. However, although the plastic hinge had developed near the ground surface, there was no evidence of delamination or shattering in this region. Only about 5 percent of the reflective sheeting surface had been lost. After ten vehicle impacts, there were slight splits down from the top, but the bottom of the post was in good condition with no shattering or delaminations. Only about 15 percent of the reflective sheeting surface was destroyed. After 10 impacts this post was in very good condition and considered serviceable in all respects.

Test No. 6 consisted of three posts driven 20 feet apart, 5 feet off the edge of the paved median shoulder in native compacted sandy clay soil. The posts were driven to a depth of 16 inches, with 44 inches remaining above the ground. The posts were flexed prior to the first impact, and were impacted 10 times head-on at 35 mph. After the first impact, there was no damage evidenced by any of the posts. After 5 impacts there was only slight damage in evidence with slight cracks near the base and at the top of the posts. All posts after 10 impacts still showed only slight damage. The hinge at the bottom showed no delamination or fraying but minor cracks existed at the tops of the posts. All posts in general looked very good and were in an excellent serviceable condition after 10 vehicle impacts at 35 mph. The first post was reflectorized with a small area of high intensity sheeting which appeared to offer better resistance to damage than the larger strips

of engineering grade sheeting on the other two posts. After the initial 10 impacts at 35 mph, the posts were hit five more times head-on at 55 mph. The 55 mph speed caused base delamination and shattering and other damage to start developing rather rapidly as was the case in the previous 55 mph vehicle impacts in Tests Nos. 1, 2, and 3.

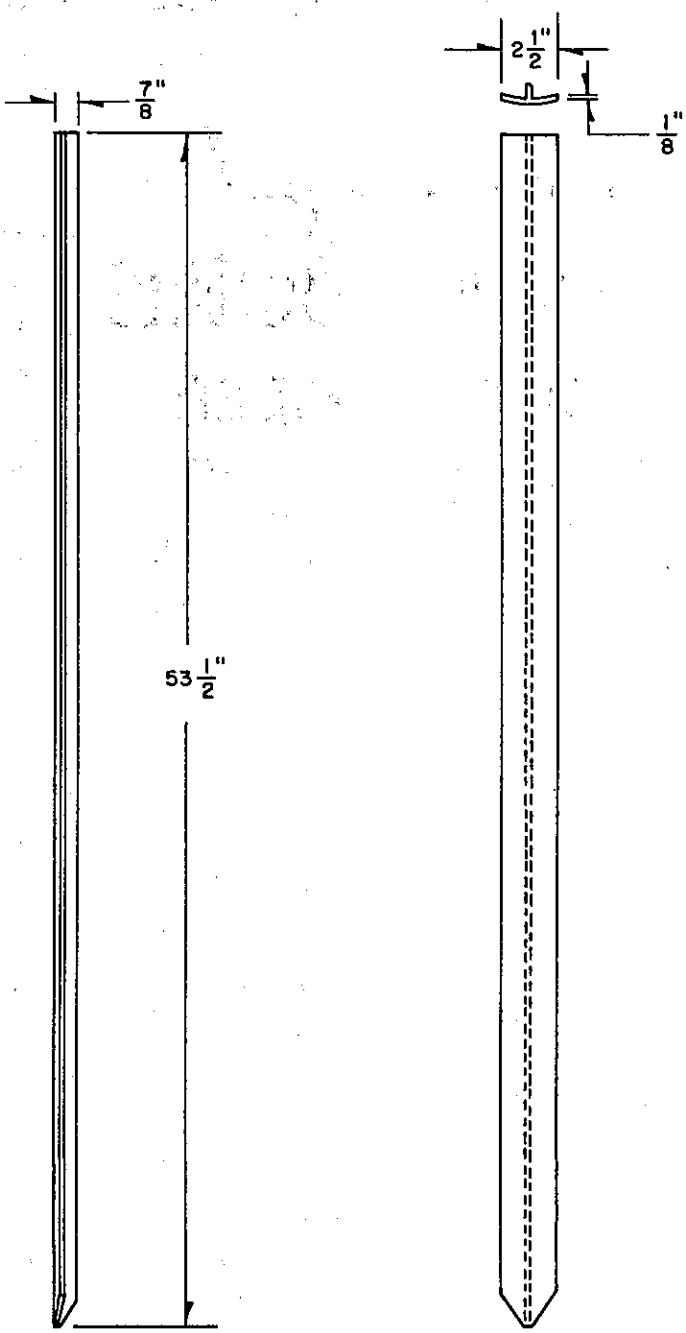
Test No. 7 consisted of three posts driven 10 feet apart in the earth about 5 feet off the edge of the paved median shoulder. The posts were impacted head-on with the test vehicle traveling at a constant speed of 45 mph. This test speed was selected based on the excellent results of previous tests on the Carsonite 3 3/4" wide ribbed post when impacted at 35 mph. It was felt that a speed of 45 mph may represent an upper limit for operational speeds on freeway on and off ramps, a vulnerable location where the performance of flexible guide marker posts would be of significant advantage. As in the majority of the previous tests on this post, the posts in this test were flexed to induce the plastic hinge by bending the top of the post through a 90° arc until it touched the ground in the the same direction it would be deflected on impact with the test vehicle. The posts were impacted 10 times with the test vehicle. The performance of the posts was very similar to that reported in Test No. 2 above, a 55 mph test series. The posts performed well up to and including 5 impacts. Delamination at the hinge area of the post became significant after 5 impacts and progressed with each additional impact. The tops of the posts also splintered to varying degrees from the effects of the 10 impacts but to a lesser degree than in the 55 mph tests. All three of the posts in this test were reflectorized with a 3" by 4" piece of High Intensity reflective sheeting. It is significant to note that this material withstood the 10 impacts in a very satisfactory manner, suffering some scrapes and minor holes, but remaining essentially intact.

In summary, this 3 3/4 inch wide Carsonite flexible delineator post was easily driven in the soil at the test location. However, it could not be driven through the paved AC shoulder and underlying crushed rock base layer. The post appeared to be almost indestructible when impacted 10 times head-on at 35 mph. However, it could not withstand 10 head-on impacts at 55 mph, nor at 45 mph, and remain in serviceable condition. This Carsonite post suffered much greater impact damage, particularly in the plastic hinge region, when installed in pavement as compared to soil. This post appears to be able to withstand angle impacts better than head-on impacts from the standpoint of damage in the hinge region. The smaller strips of high intensity grade reflective sheeting appeared to resist impact damage better than the larger strips of engineering grade reflective sheeting. It is also significant to note that after 166 impacts by the test vehicle, the AMC Matador, no significant damage to the vehicle was noted. Ninety percent of these 166 impacts were made at speeds of 55 mph.

From the impact testing performed to date on the Carsonite flexible delineator post, it appears that for the post to reliably 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 by hand. Thus the installation instructions should include the requirement for the development of a plastic hinge in the post immediately above ground level.

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

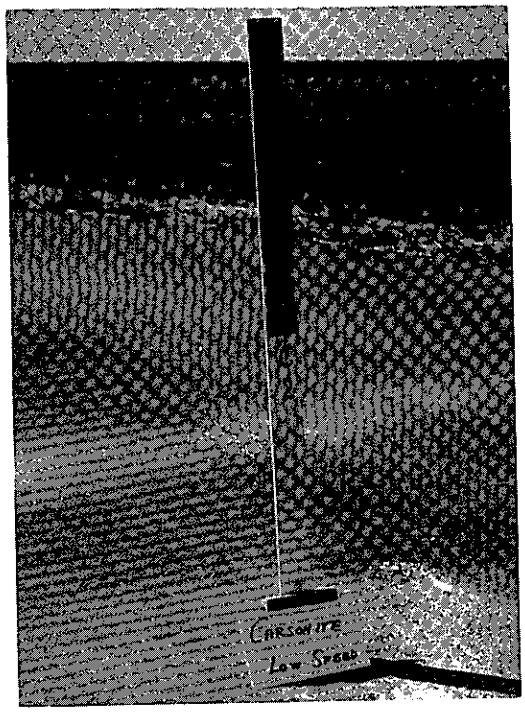
Figure 13



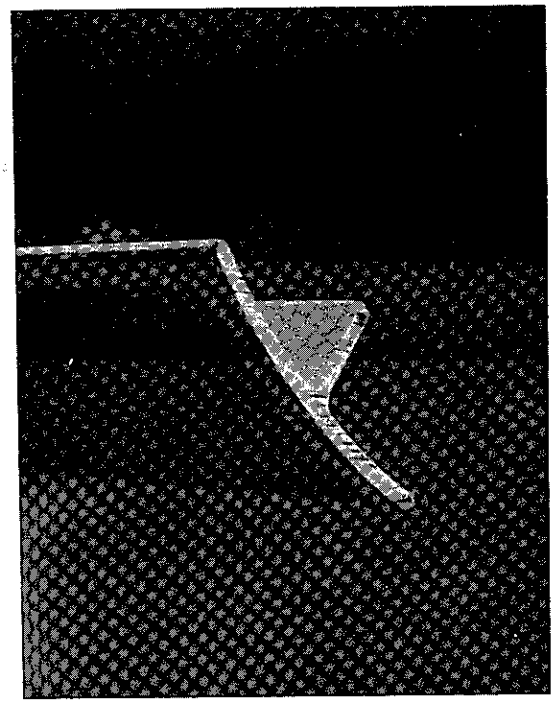
CARSONITE "TEE"
FLEXIBLE PLASTIC GUIDE MARKER &
CLEARANCE MARKER POST

CARSONITE T-POST

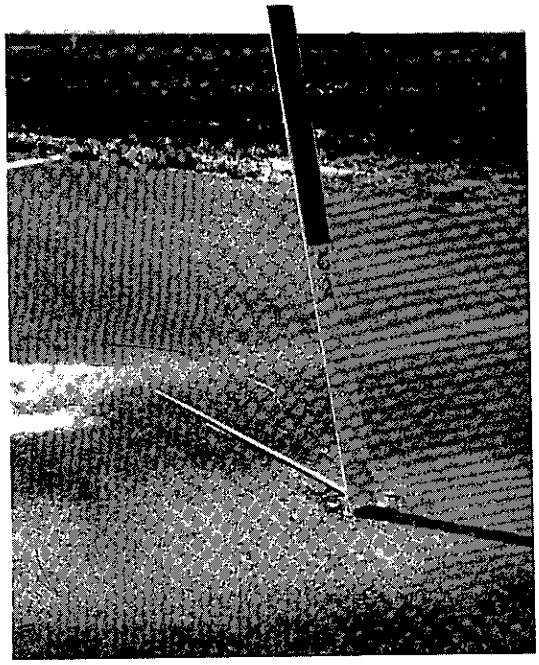
Figure 14



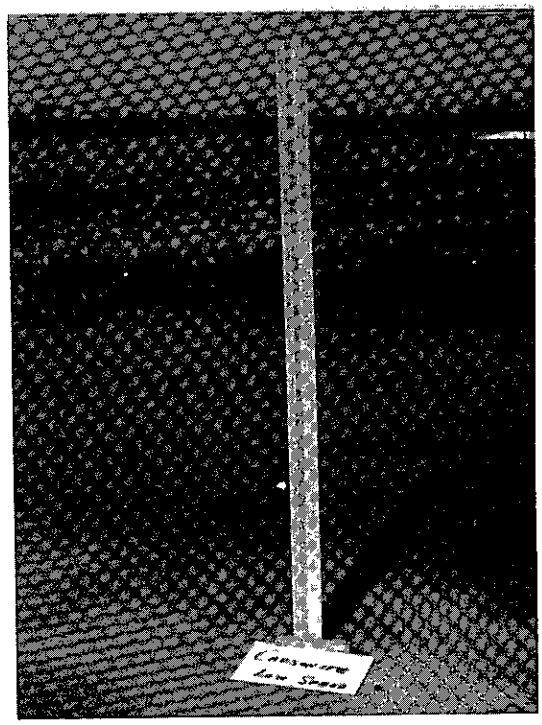
Before Impact



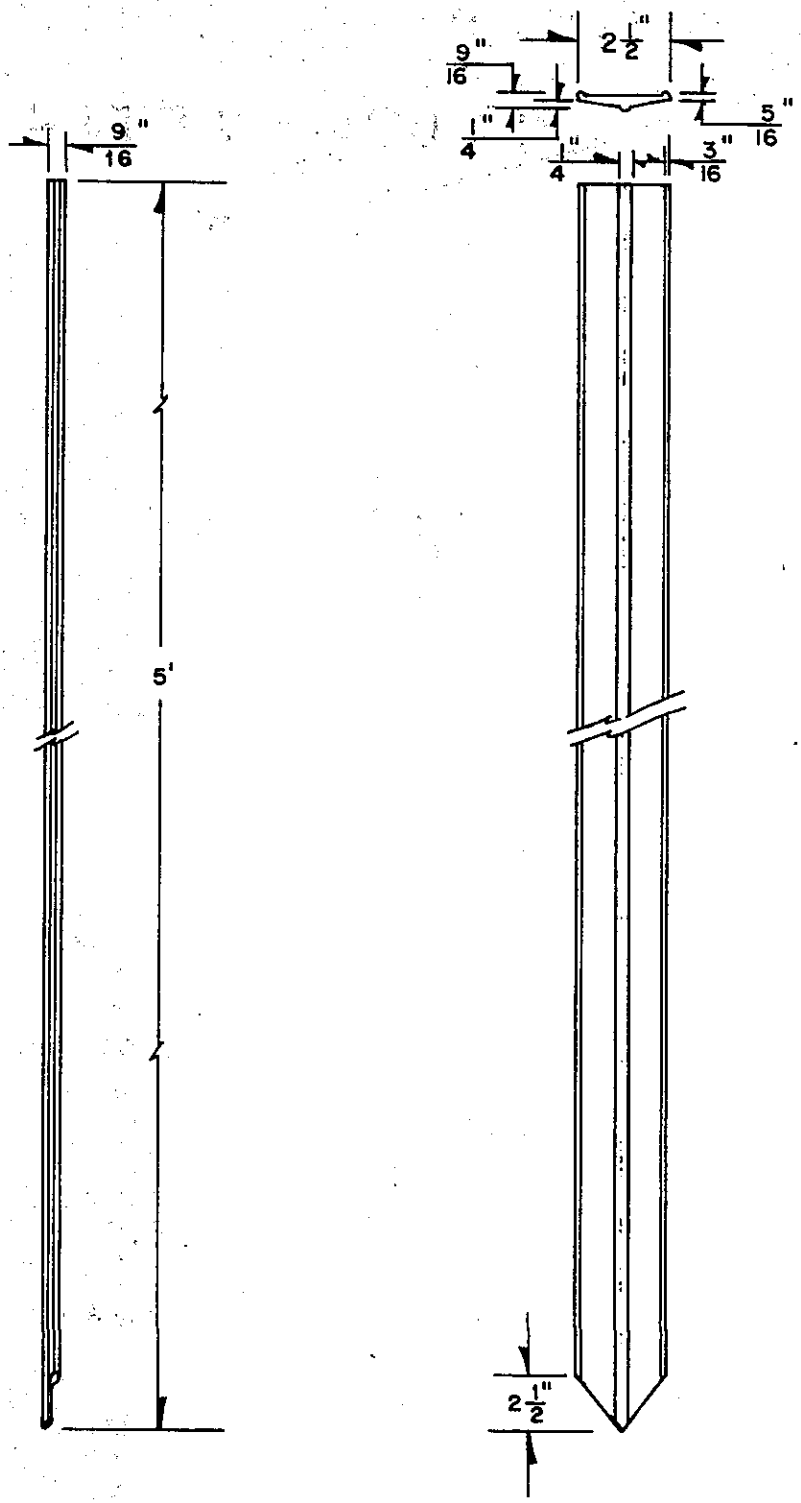
Top - Front View



After 5 Impacts

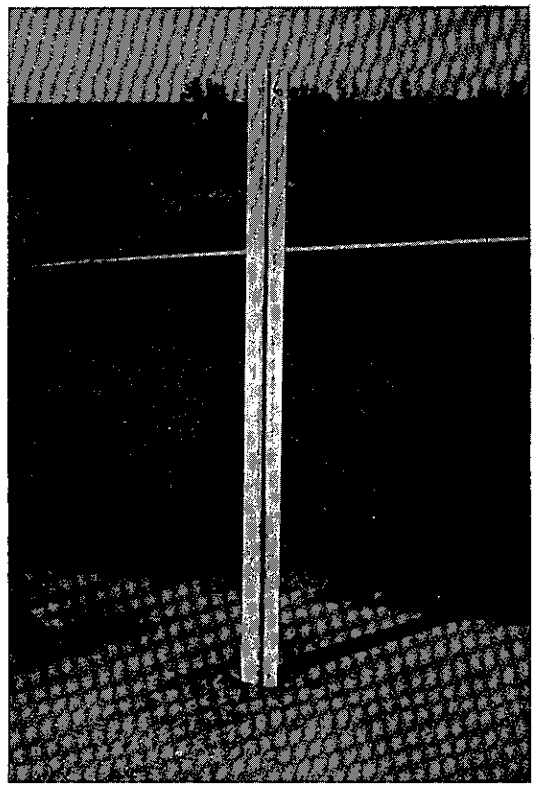


Back View - Before Impact

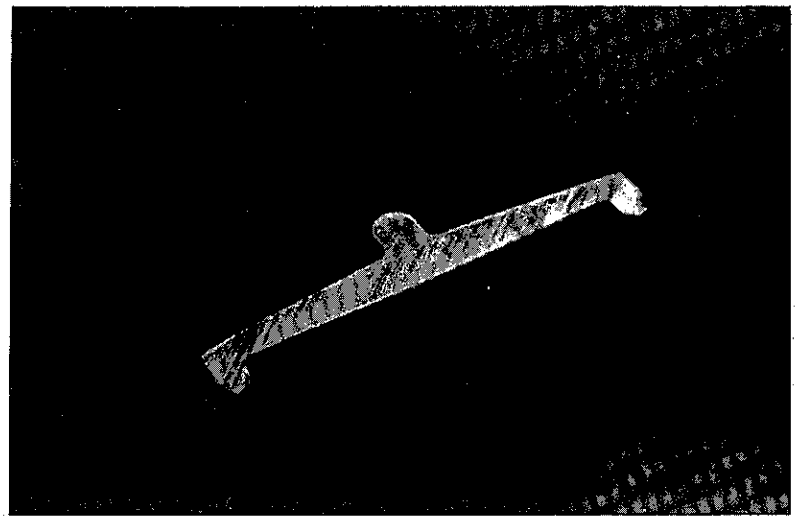


CARSONITE 2½" WIDE "RIBBED" FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

Front View - Before Impact

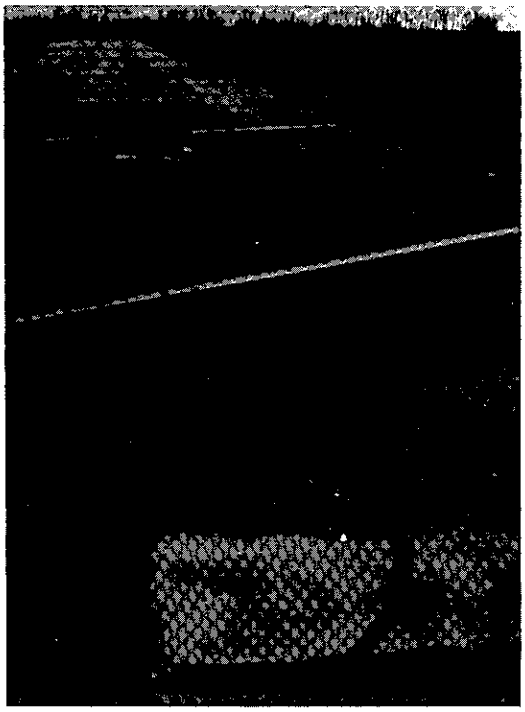


Back View - Before Impact

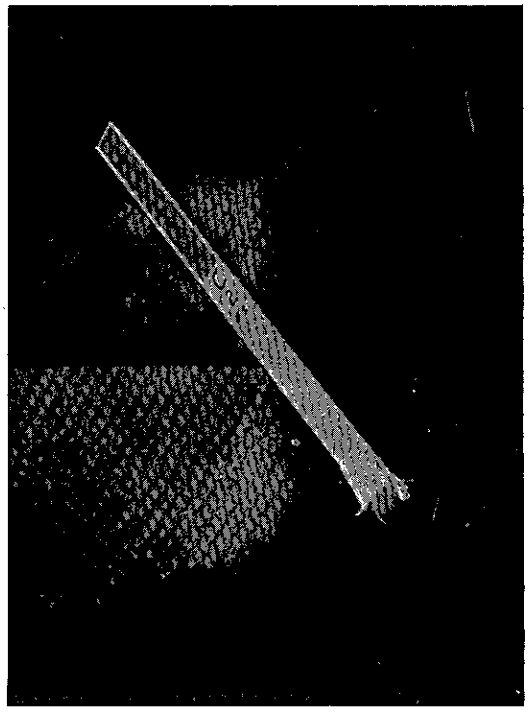


Top Front View - Before Impact

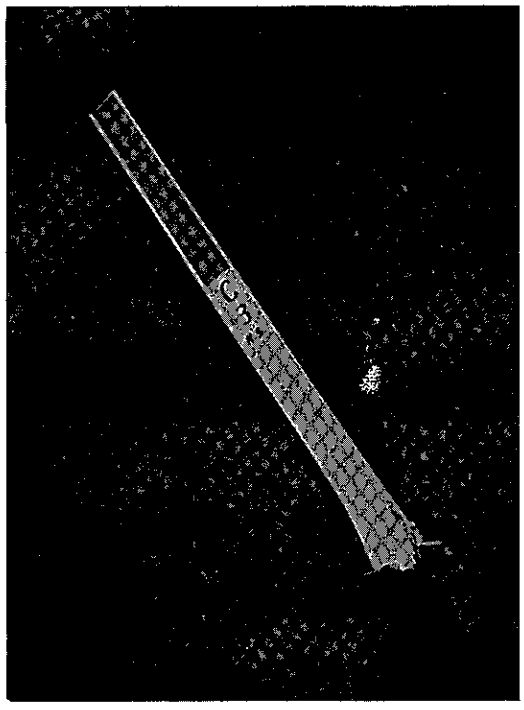
CARSONITE 2 1/2 INCH WIDE RIBBED POST Figure 17



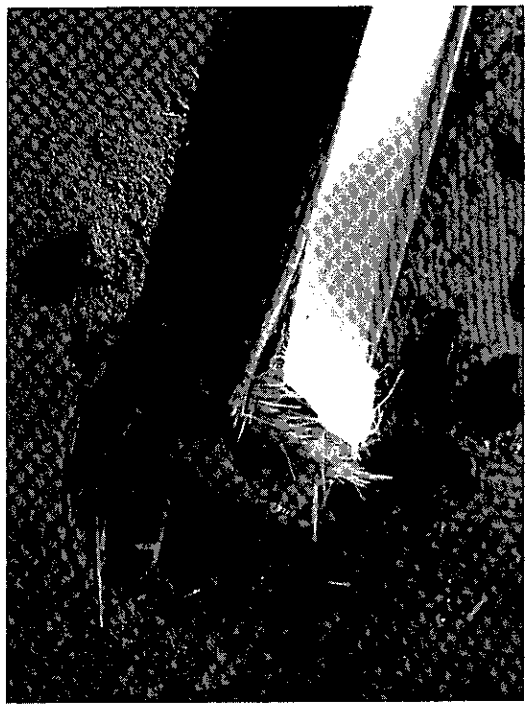
Front View - Before Impact



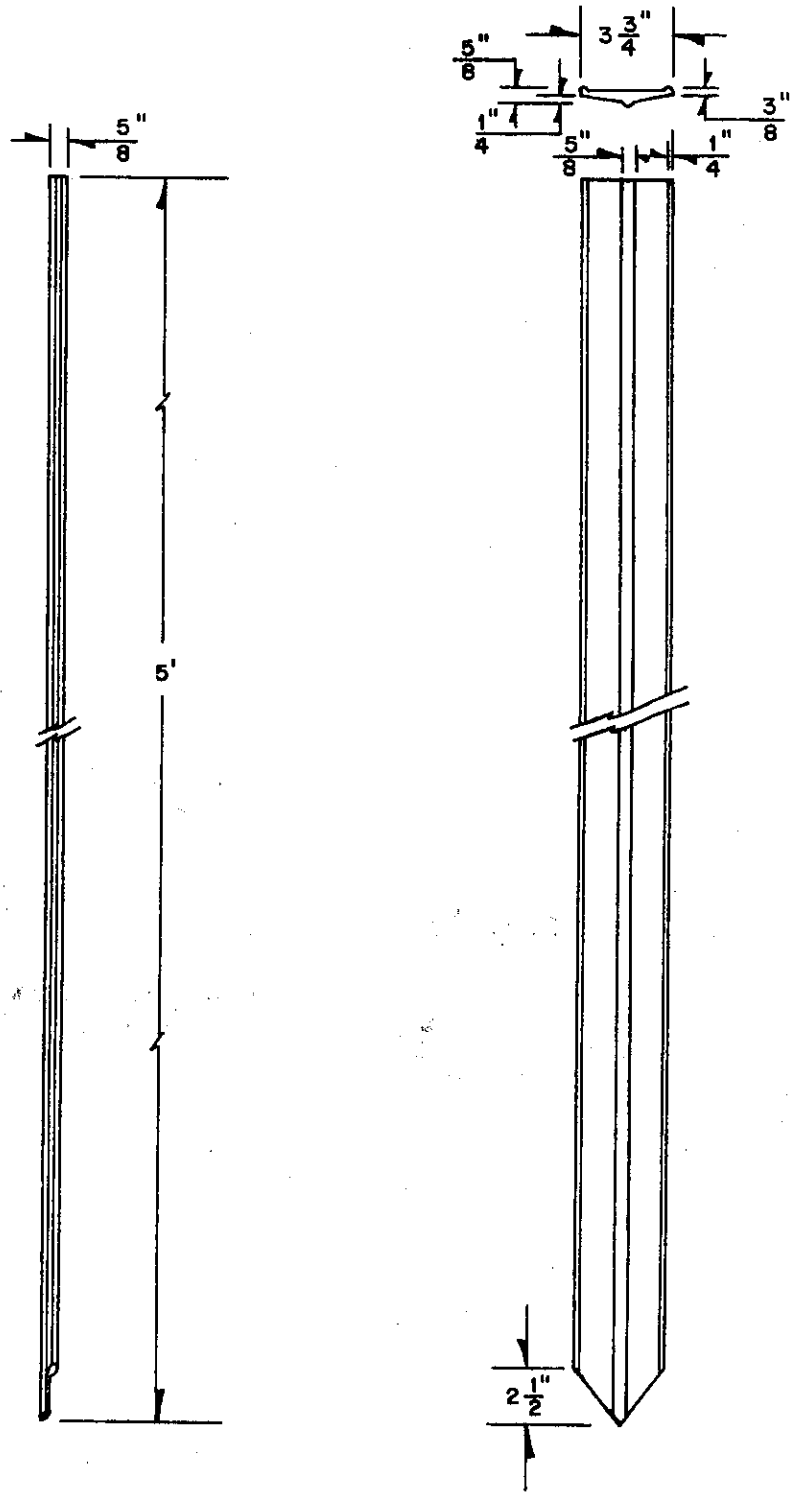
After Impact



After Impact



After Impact



CARSONITE $3\frac{3}{4}$" WIDE "RIBBED" FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

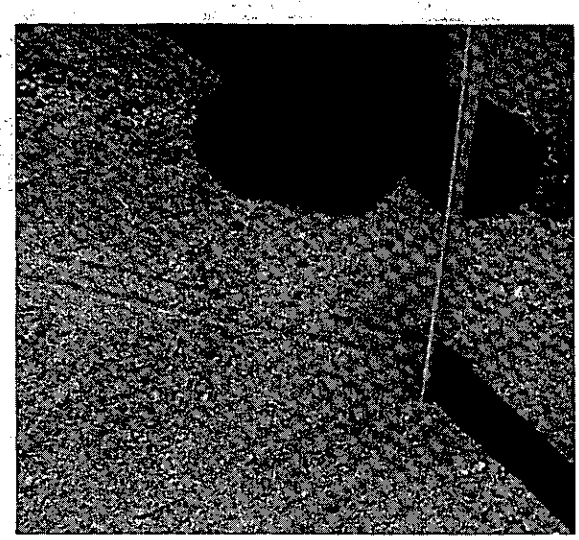


Figure 19B
Side View - After Impact

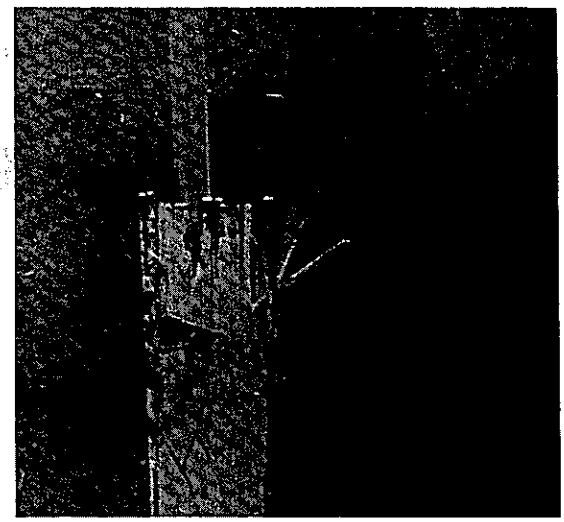


Figure 19A
Front View - After 10 Impacts

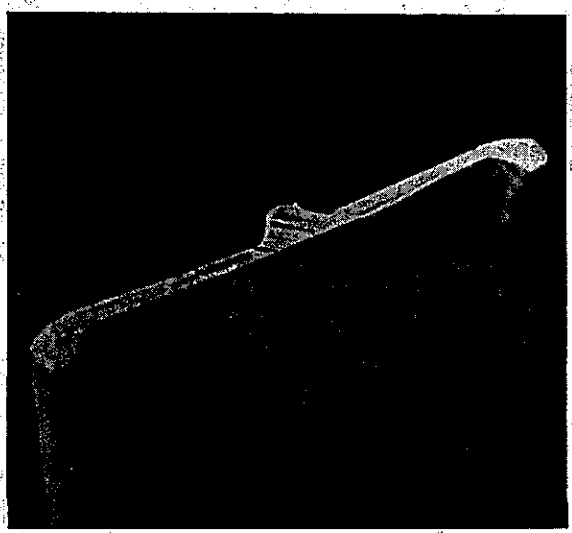


Figure 19D
Top - Front View

Figure 19C
Installing the Posts

VI. APPENDIX

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY

PROPOSED SPECIFICATIONS FOR DRIVEABLE FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POSTS

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.

D. Marking

The top of the post on the side away from traffic shall be date stamped showing the month and year of fabrication. The numerals shall be at least 1/4 of an inch in height and shall be either die stamped or legibly stamped with permanent ink.

III. GENERAL REQUIREMENTS

A. Dimensions

1. Width

The post shall have a minimum width of 3 inches facing traffic.

2. Length

The post shall be of such length to provide a height of 48 inches above the ground surface unless otherwise specified, 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 12 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.

a. The post shall not be adversely affected 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 friction-less 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 con-stitute 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 resistant material and be so designed that an installed post is capable of self erecting and remaining serviceable after being subjected to a series of direct impacts by a typical passenger sedan at temperatures of 40°F or above. The posts to be tested shall be installed in accordance with the re-commendations of the manufacturer. The posts shall be furnished complete with attached reflectors proposed for use. Posts shall be capable of withstanding a series of 10 impacts headon (90°) into the traffic face of the post at a speed of 35 mph. Posts shall also be capable of with-standing a series of 5 impacts at an angle of 75° to the traffic face of the post at a speed of 55 mph. The impacting vehicle shall suffer little or no damage during the impact test series.

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. The reflector shall have a minimum projected area of 36 square inches and have a minimum size of 3 inches by 12 inches. The reflector shall be of Type I or Type II reflective sheeting as specified.

B. Mounting

The reflector shall be mounted on the top 14 inches of the post with the reflector facing in the direction of the on-coming traffic. The reflector 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
Type I Reflective Sheeting

Divergence Angle (°)	Incidence Angle (°)	Silver White	Yellow
0.2	- 4	70	40
0.2	+15	53	29
0.2	+30	30	14

MINIMUM DRY REFLECTIVE INTENSITY VALUES
Type II Reflective Sheeting

Divergence Angle (°)	Incidence Angle (°)	Silver White	Yellow
0.2	- 4	250	150
0.2	+15	185	110
0.2	+30	60	35

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.

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. Test data submitted by the manufacturer may be subject to verification by suitable tests conducted by the California Department of Transportation prior to prequalification for bidding.

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.

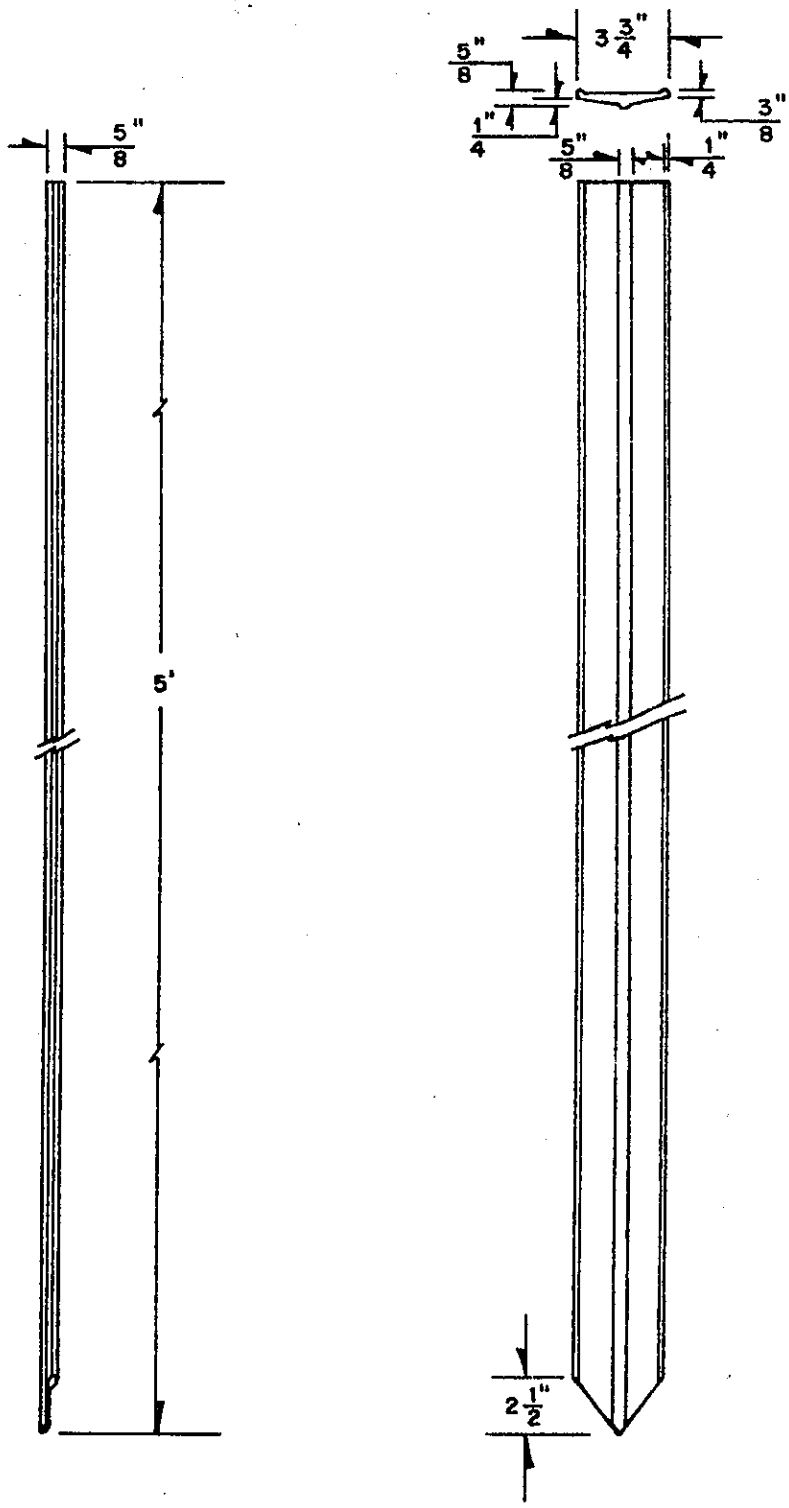
VII. PATENTS

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



CARSONITE 3¾" WIDE "RIBBED" FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST

STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY

PROPOSED SPECIFICATIONS FOR FLEXIBLE PLASTIC GUIDE MARKER AND CLEARANCE MARKER POSTS

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) Indentification of the person responsible for quality control and his authority in the organization.

D. Marking

The top of the post on the side away from traffic shall be date stamped showing the month and year of fabrication. The

numerals shall be at least 1/4 of an inch in height and shall be either die stamped or legibly stamped with permanent ink.

III. GENERAL REQUIREMENTS

A. Dimensions

1. Width

The post shall have a minimum width of 3 inches facing traffic.

2. Length

The post shall be of such length to provide a height of 48 inches above the ground surface, unless otherwise specified, 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 12 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. Tensile Strength Properties

a. The post shall have a minimum tensile 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 D 638 (Test Specimen Type 1). The rate of jaw separation shall be 20 inches per minute.

2. Heat Resistance

a. 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.

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

3. 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.

a. The post shall be sufficiently flexible to permit four 90° 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 and 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 and be so designed that an installed post is capable of self erecting and remaining serviceable after being subjected to a series of direct impacts by a typical passenger sedan at temperatures of 40°F or above. The posts to be tested shall be installed in accordance with the recommendations of the manufacturer. The posts shall be furnished complete with attached reflectors proposed for use. Posts shall be capable of withstanding a series of 10 impacts headon (90°) into the traffic face of the post at a speed of 35 mph. Posts shall also be capable of withstanding a series of 10 impacts at an angle of 75° to the traffic face of the post at a speed of 55 mph. The impacting vehicle shall suffer little or no damage during the impact test series.

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, Transportation Laboratory. The reflector shall have a minimum projected area of 36 square inches and have a minimum size of 3 inches by 12 inches. The reflector shall be of Type I or Type II reflective sheeting as specified.

B. Mounting

The reflector shall be mounted on the top 14 inches of the post with the reflector facing in the direction of the on-coming traffic. The reflector 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
Type I Reflective Sheeting

Divergence Angle (°)	Incidence Angle (°)	Silver White	Yellow
0.2	- 4	70	40
0.2	+15	53	29
0.2	+30	30	14

MINIMUM DRY REFLECTIVE INTENSITY VALUES
Type II Reflective Sheeting

Divergence Angle (°)	Incidence Angle (°)	Silver White	Yellow
0.2	- 4	250	150
0.2	+15	185	110
0.2	+30	60	35

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 detemining 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 D 523.

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. Test data submitted by the manufacturer may be subject to verification by suitable tests conducted by the California Department of Transportation prior to prequalification for bidding.

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 re-samples pass, the lot will be accepted.

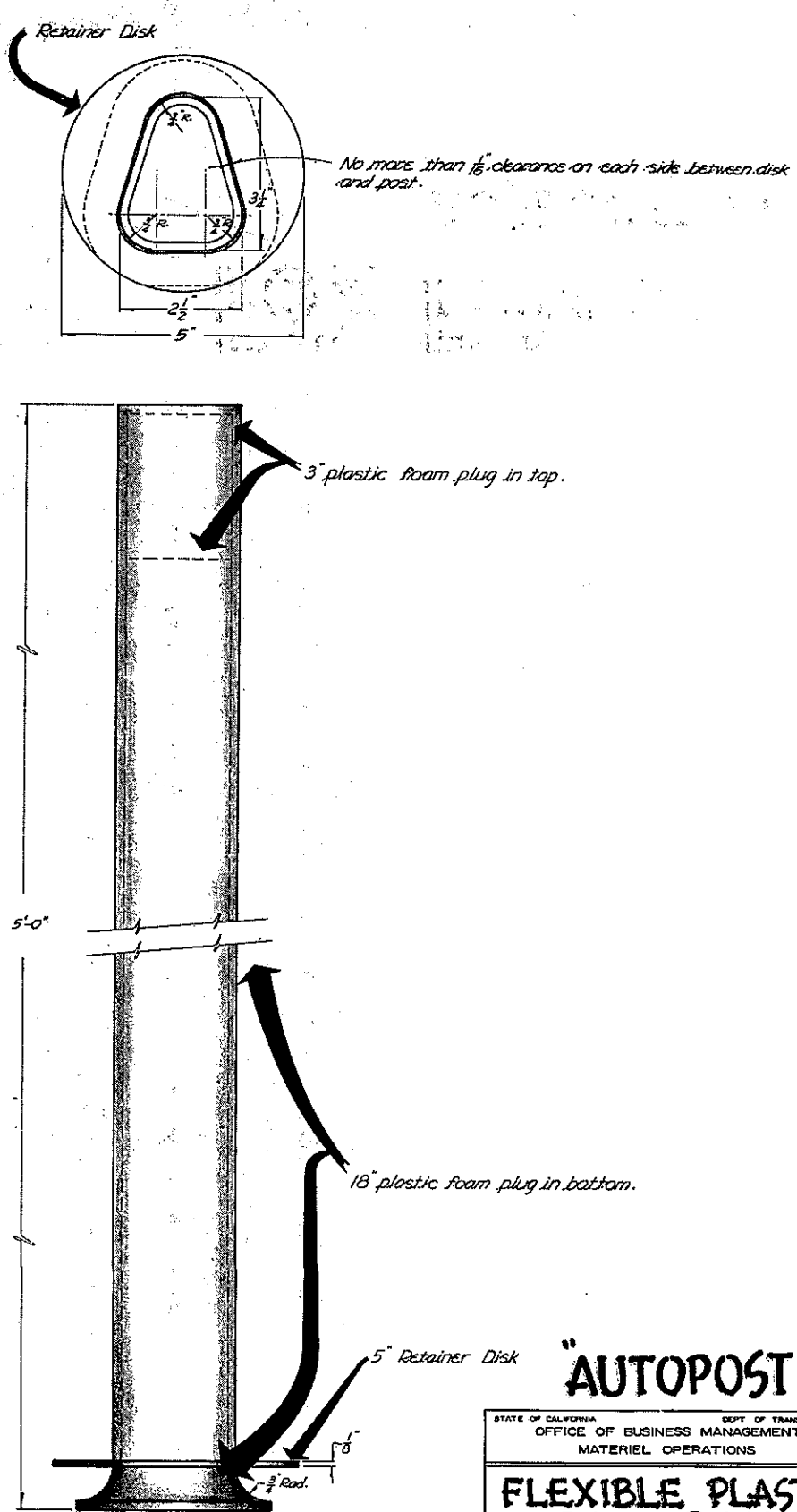
VII. PATENTS

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 the following manufactured posts shown on the attached drawings have been found to comply with these specifications:

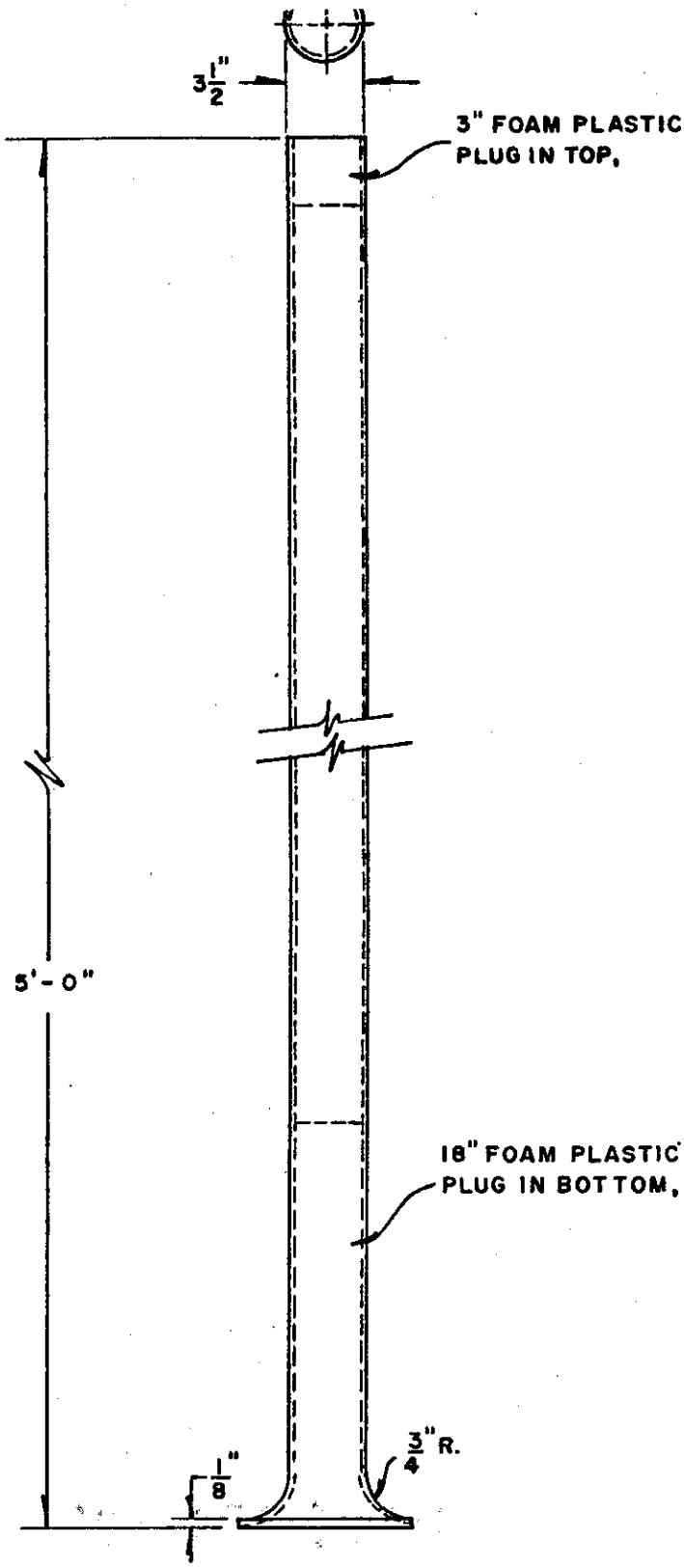
1. Autopost
2. Polypost
3. Lanco - Model LDP-6



"AUTOPOST"

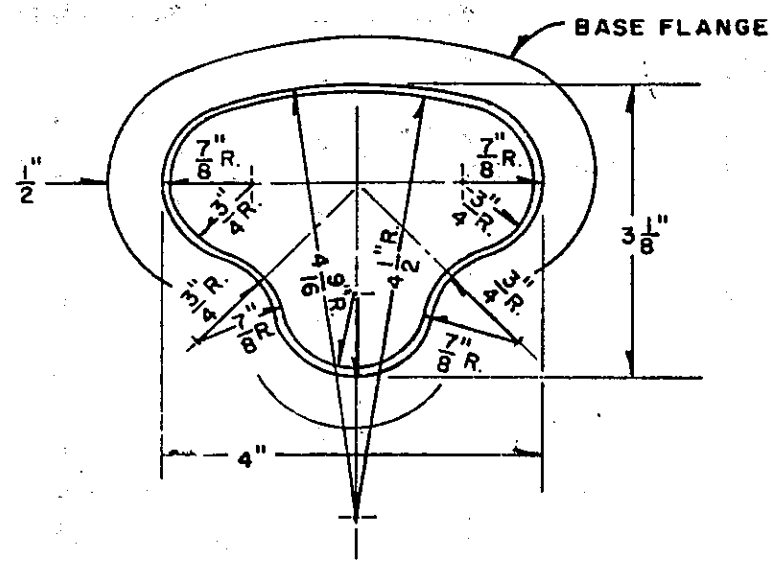
STATE OF CALIFORNIA — DEPT OF TRANSPORTATION
OFFICE OF BUSINESS MANAGEMENT
MATERIEL OPERATIONS

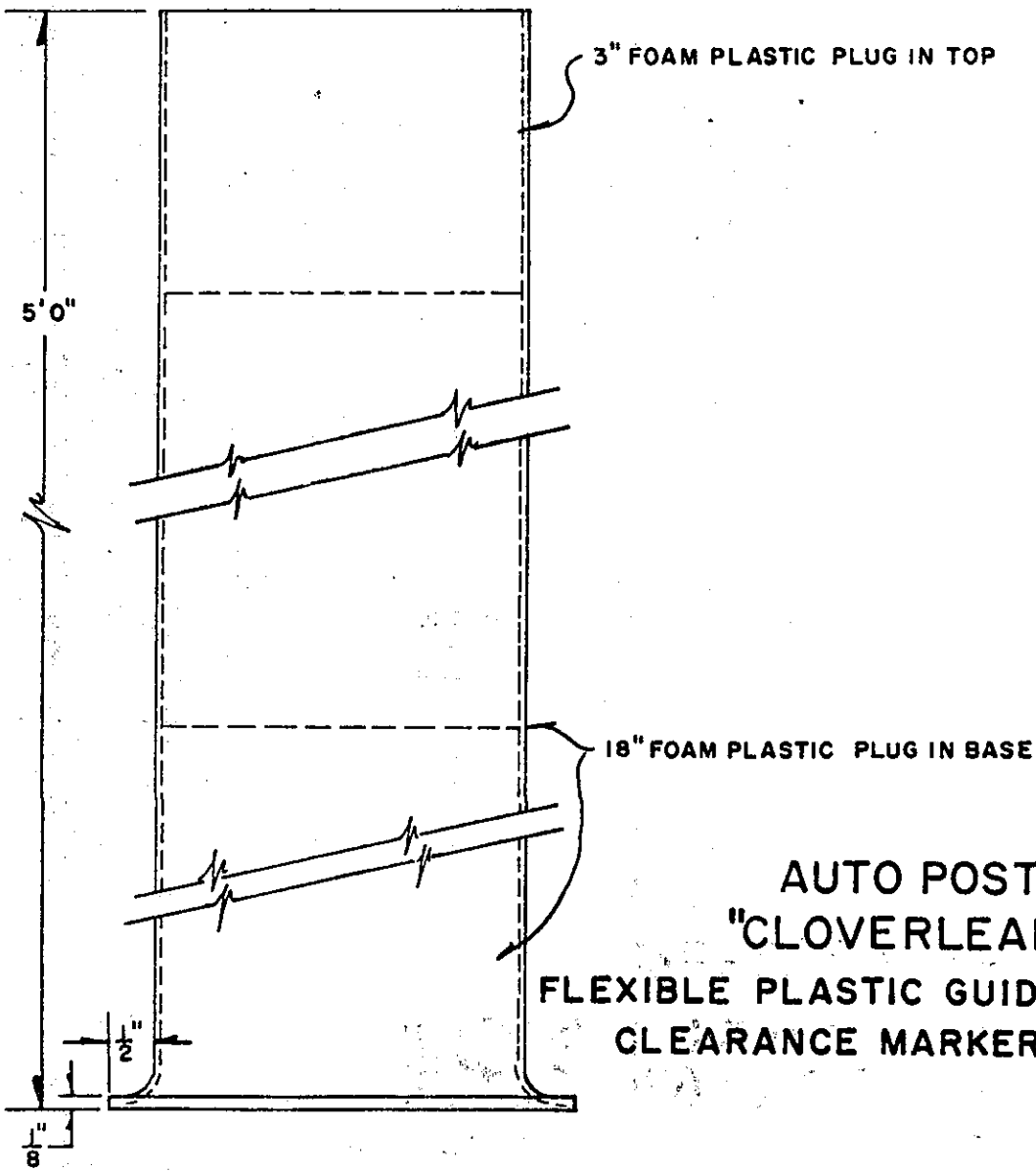
FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST



AUTOPOST, CIRCULAR

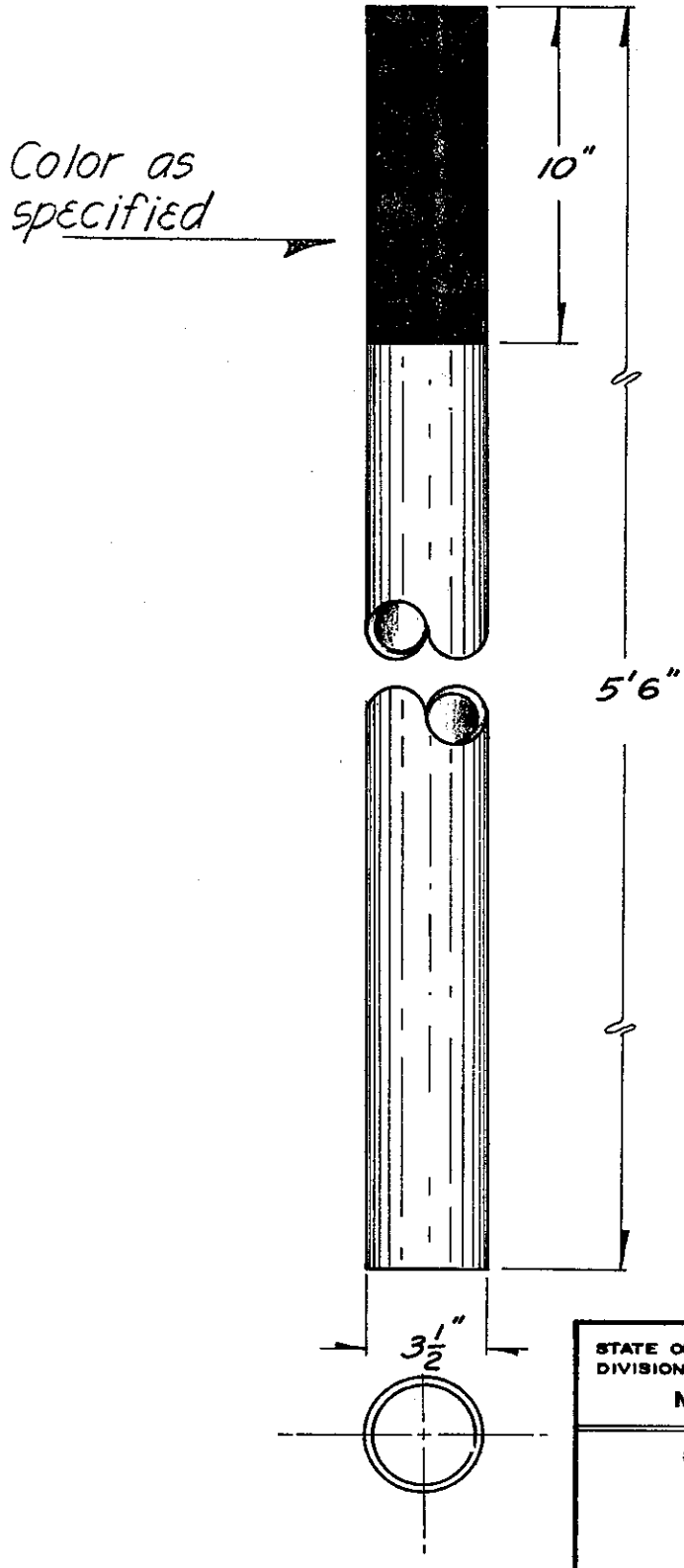
FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST





AUTO POST "CLOVERLEAF"

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST



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DIVISION OF ADMINISTRATIVE SERVICES — O. B.M.
MATERIEL OPERATIONS

"Polypost"

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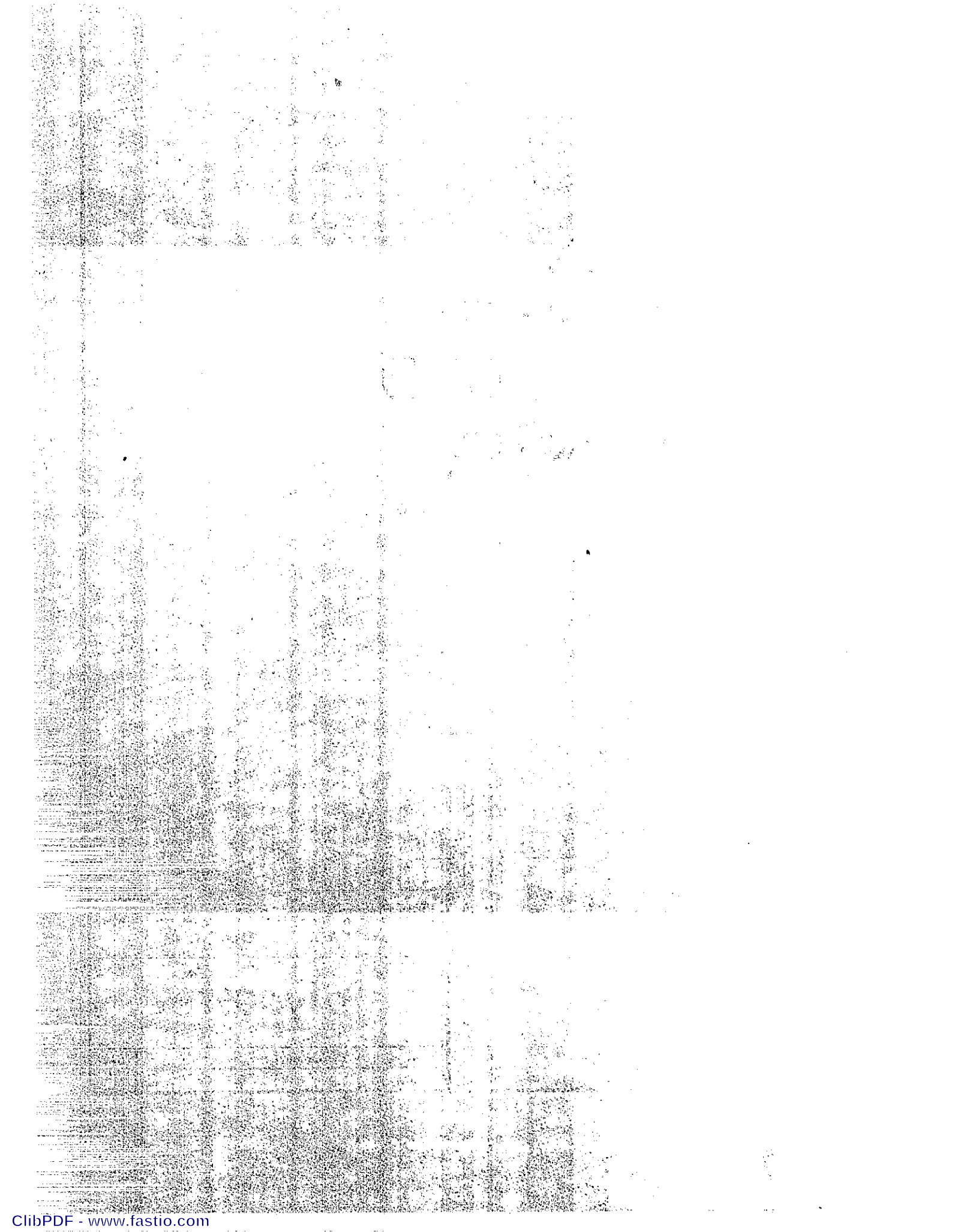

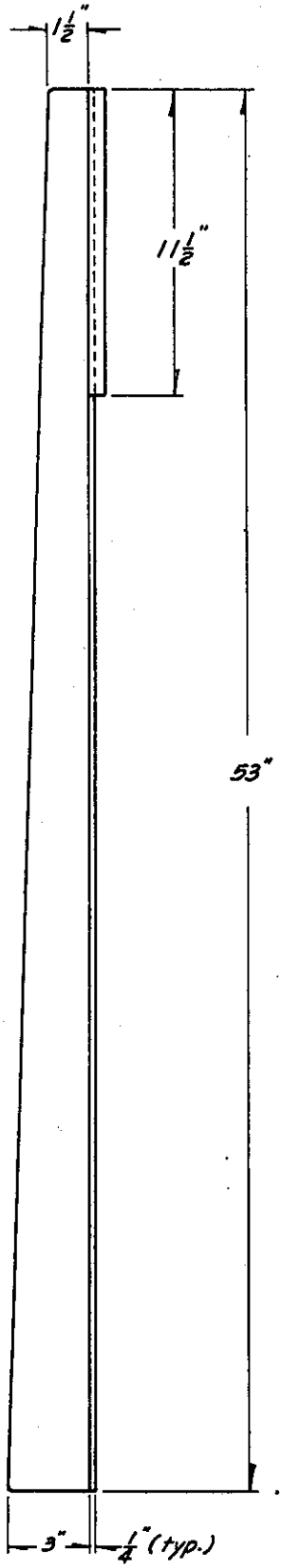

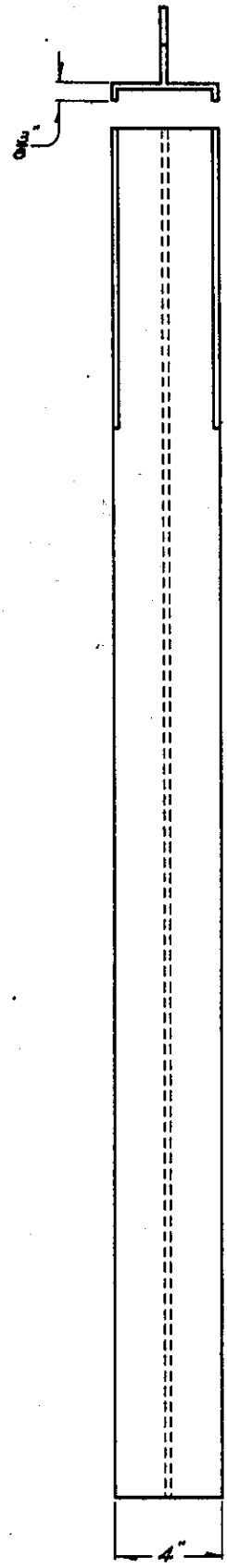

LANCO-LDP-6

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MATERIEL OPERATIONS

FLEXIBLE PLASTIC GUIDE MARKER & CLEARANCE MARKER POST