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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
NEW TECHNOLOGY & RESEARCH PROGRAM
OFFICE OF INFRASTRUCTURE RESEARCH

# DEVELOPMENT OF QUICK CHANGE BREAKAWAY SIGN SUPPORT SYSTEMS TO BE USED AS AN ALTERNATIVE TO INSTALLING SMALL WOOD POSTS IN AUGERED HOLES IN SOIL

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## 16. ABSTRACT


The Caltrans sign maintenance crews, install and replace small wooden roadside signposts in certain locations where exposure to traffic is a particular concern. Caltrans designed, fabricated, installed, tested, and monitored a new type of permanent reusable foundation system. This system would enable sign maintenance crews to remove knocked down 89 mm x 89 mm (4” x 4”) or 89 mm x 140 mm (4” x 6”) wood sign post stubs quickly and replace the damaged post with a new post and sign within 10 minutes for typical installations. The successfully tested system will be adopted for statewide use.

Several Districts in Northern California participated in the implementation phase of this Project. From the results, many of the replacement times that were faxed in from the sign crews have been within the desired 10 minute time frame, some as low as 4 minutes. There have been instances where the reported times were as long as 45 minutes. In one case, the signpost was hit from the opposite direction, which cracked the footing, demolished the wedges and pushed the footing out of plumb. In another instance, the footing was out of plumb from two hits, but it was reported that conditions during the footing installation were muddy. Overall, the crew responses have been favorable and a limited number of requests for more footings continue to be received.


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## CONVERSION FACTORS

| Quantity | SI Unit | Divide By | To Get Equivalent English Unit |
|---|---|---|---|
| Length | millimeters (mm) | $2.54 \times 1\ 10^{1}$ | inches |
| | meters (m) | $2.54 \times 10^{-2}$ | inches |
| | meters (m) | $3.048 \times 10^{-1}$ | feet |
| | kilometers (km) | 1.609 | miles |
| Area | square meters ($m^2$) | $6.452 \times 10^{-4}$ | square inches ($in^2$) |
| | square meters ($m^2$) | $9.29 \times 10^{-2}$ | square feet ($ft^2$) |
| Volume | liters (l) | 3.785 | U.S. gallon (gal) |
| | cubic meters ($m^3$) | $2.832 \times 10^{-2}$ | cubic feet ($ft^3$) |
| | cubic meters ($m^3$) | $7.646 \times 10^{-1}$ | cubic yard ($yd^3$) |
| Mass | kilograms (kg) | $4.536 \times 10^{-1}$ | pounds (lbm) |
| Density | kilograms per cubic meter ($kg/m^3$) | $1.602 \times 10^{1}$ | ($lb/ft^3$) |
| Force | Newton (N) | 4.448 | pounds (lb.) |
| | Newton (N) | $4.448 \times 10^{3}$ | kips (1000 lb.) |
| Bending Moment or Torque | Newton-meters (Nm) | $1.130 \times 10^{-1}$ | inch-pounds (in-lb.) |
| | Newton-meters (Nm) | 1.356 | foot-pounds (ft-lb.) |
| Pressure | Pascal (Pa) | $6.895 \times 10^{3}$ | pounds per square inch (psi) |
| | Pascal (Pa) | $4.788 \times 10^{1}$ | pounds per square foot (psf) |
| Temperature | degrees Celsius (°C) | °C * 1.8 + 32 = °F | degrees Fahrenheit (°F) |

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DEVELOPMENT OF QUICK CHANGE BREAKAWAY SIGN SUPPORT SYSTEMS
TO BE USED AS AN ALTERNATIVE TO INSTALLING SMALL WOOD POSTS
IN AUGERED HOLES IN SOIL

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# 1 INTRODUCTION

The purpose of this research project was to develop a footing for 89mm x 89mm and 89mm x 140mm (Refer to, from this point on, the English Nominal Dimension of 4” x 4” and 4” x 6”) wood signposts which would allow for replacement times that are substantially less than for posts that are placed in augered holes in soil. The end-result is a concrete footing with a specially shaped cavity into which the signpost is inserted and secured with reusable recycled plastic wedges. This system typically allows for replacement of a broken wood signpost in 10 minutes or less.

## 1.1 Problem

Presently the California Department of Transportation (Caltrans) sign maintenance crews must install and replace small wooden roadside signposts in certain locations where exposure to traffic is of particular concern. These locations include gore areas, tight curves, narrow shoulders, and medians. Signs that are frequently downed in these locations include EXIT, MERGE, DO NOT ENTER, CURVE, and STOP signs.

A typical signpost replacement takes 30 to 40 minutes for a two-person crew. It involves: removal of the broken stub, auguring a new hole, bolting on the sign panel, placing the post in the hole, and compacting the fill. During this entire time, the sign crew and their installation equipment are exposed to potentially hazardous traffic conditions. Their presence on the highway can create a more complicated driving or traffic condition by presenting new and unusual circumstances to motorists, some of which may be impaired or simply inattentive. Anything that can be done to reduce the time needed to remove and replace a downed signpost will decrease the risks for Caltrans crews as well as the motoring public.

## 1.2 Objectives

The objective of this project was to develop a new type of permanent reusable foundation system, which will enable sign maintenance crews to replace damaged 4"x 4" or 4"x 6" wood signposts within 10 minutes.

## 1.3 Scope

To achieve the objective of this project, a prototype footing was built from preliminary design criteria. The functionality and constructability of this first footing was then evaluated to determine where improvements could be made. The subsequent design was fabricated and more rigorous testing was done prior to placing samples on the roadway for evaluation by Maintenance crews. This monitoring period identified and resolved potential problems, which could only be determined under field conditions. A Standard Special Provision will be drafted and made available for inclusion in future contracts. To aid implementation, the concrete footing fabrication methods and equipment will be made available to the Districts as requested. These Districts may then produce as many footings as desired using concrete from local sources. A number of the footings will be stocked until December 1999 at the Caltrans Transportation Laboratory in Sacramento, California for local Districts or, if special circumstances warrant, shipment to a more distant District.

## 1.4 Literature Search

A literature search was performed at the beginning of the project to find an alternative to the methods and materials used to erect roadside signposts, particularly 4"x 4" or 4"x 6" posts. Various databases, including METADEX, NTIS, TRIS, and COMPENDEX PLUS were searched using DIALOG Information Services. Information was gathered on various types of proprietary signpost systems, which involved steel posts and some sort of breakaway hardware. No information was found relating to any previous studies or research on reusable foundations using wood signposts.

## 1.5 Background

Thirty-six Caltrans employees were fatally struck by errant drivers between 1972 and 2000.[1] Some of these were in the process of replacing one of the approximately 23,000 small signs supported by single 4"x 4" or 4"x 6" wood signposts knocked down annually by errant motorists. Roadside sign replacement along California's highways is a daily routine for Caltrans sign maintenance crews. The task of replacing a typical downed sign will take a two-person crew 30 to 40 minutes if a lane closure is not required. A typical non-lane closure replacement involves the following steps:

1. removal of the broken wood signpost stub using a pick, pry bar, or shovel,
2. cleaning of the hole using a manual post hole digger or power auger[2],
3. mounting a sign panel on the new post,
4. cutting the new post to the required length (if necessary),
5. inserting the post into the hole,
6. making sure the post is plumb while backfilling and tamping the soil.

## 1.6 Overview of Report Contents

This report describes the problem with the current method of sign placement, the proposed alternative, prototype development and testing, design changes, construction techniques and problems, dynamic testing of the final design, installation and replacement procedures, field evaluations, conclusions, recommendations, and implementation procedures.

# 2. PROPOSED ALTERNATIVES

The Caltrans Design for Safety Concept Action Group (DSCAG) recognized the risk of serious injury to maintenance personnel due to errant traffic while replacing these downed signposts. DSCAG requested assistance from the Office of Structural Materials of the Division of Materials Engineering and Testing Services (METS)[3] to develop a new signpost system that would reduce replacement times.

The first step was to investigate what products were currently being used by other State DOTs and to determine if they would meet the objective of this project. It was also deemed important that the sign crews would not have to deal with a wide variety of signpost products and associated hardware.

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[1] From the Caltrans Fact Sheet, “Highway Workers Safety” website. (http://www.dot.ca.gov/hq/paffairs/about/safety.htm)

[2] Occasionally the hole is left intact and sign crews merely insert a new post into the hole and tamp the surface soil. This method does not secure the post well enough and it will eventually lean due to wind forces. This method is not approved in the Caltrans Maintenance Manual.

[3] During the re-organization of Caltrans, this project was re-assigned from the Division of Materials Engineering and Testing Services to the Office of Research within the New Technology & Research Program.

## 2.1 Steel breakaway posts

There are a number of commercially available steel signposts with some sort of breakaway feature. These products were investigated by talking to the manufacturer and with other State DOTs that use them. It was decided to find an alternative that would still use the traditional wood signposts because maintenance crews were familiar with handling wood signposts and to prevent the crews from having to carry additional tools, equipment, and fasteners.

## 2.2 Fiberglass posts

One company produces a fiberglass post filled with a lightweight concrete for use with roadside signs. As with the steel breakaway posts, this product was investigated by talking to the manufacturer and with other State DOTs. Again, it was decided to find an alternative that would still use the traditional wood signposts for the same reasons listed above.

## 2.3 Early wood-in-steel footings

A few tubular steel sockets intended to be used with wood signposts have been proposed in the past. The cavities of these proposed steel sockets have parallel sides with large radius corners, and a fixed internal dimension that must be large enough to accept the largest allowable dimensional variation in wood signposts. The dimensions of the wood posts used by Caltrans are allowed to vary considerably as they may be either surfaced or rough sawn, and either wet or dry. These early footings had no provision for securing the post into the socket or cavity if the signpost is undersized.

## 2.4 Proposed wood-in-concrete footing

A brainstorming session was conducted by the Caltrans Headquarters Division of Maintenance and attended by personnel from three maintenance districts, Division of Traffic Operations, METS, and the Office of Infrastructure Research. The outcome was a recommendation to design, build, install, and evaluate a new type of reusable concrete foundation utilizing a set of wedges, which would allow quick removal of broken signpost stubs and accept standard size wood posts. The prototype foundation system would be subjected to dynamic tests and field trials to verify acceptable performance and establish actual replacement time.

# 3. PROTOTYPE DEVELOPMENT

The design process for the prototype footing involved the consideration of many different topics. Foremost was that it had to be able to securely hold a wood signpost perpendicular to the ground for long duration under all types of wind and weather conditions and in all of the many different types of soils found throughout California. The footing must also maintain that position even after the signpost is impacted and broken away, and still allow a sign maintenance crew to quickly remove the broken stub and replace the signpost. Finally, it should be as small and light as possible to allow easy transportation and handling prior to initial installation.

The final design consists of a cylindrical concrete footing that has a specially shaped cavity into which a wood signpost is inserted. The cavity is designed to allow wedges to be used at the top surface of the footing to secure the signpost into the cavity. The wedges are designed for easy removal using tools already carried by the sign crews. The wedges are made of a material that can withstand a large number of hit/replacement cycles.

### 3.1 Prototype wedge characteristics

The wedge material chosen for this project is manufactured by Collins & Aikman and sold under the brand name of $ER^3$ ™. It is made from recycled carpet fibers that are formed into blocks in an extrusion process and sold for industrial flooring purposes. It was selected because it is a very tough material that can be shaped and cut using ordinary hand and power tools, does not readily absorb moisture (non-swelling), and is environmentally benign in this application. It was purchased as 6" x 8" x 24" long blocks which were cut into the desired wedge shapes using a power band saw.

Two different taper profiles were used in the prototype wedge design. One had a taper of 1.5" over 18" of length (4.8°) while the other had a taper of 2.5" over 12" of length (11.8°). These profiles were selected to determine what type of profile would provide an adequate clamping force between the concrete and the signpost while keeping the overall length of the wedges as short as possible. The taper profile also dictates how much of the wedge will protrude above the top surface of the footing if a dimensionally large signpost (e.g. rough cut) is used. Conversely, if a dimensionally small signpost is used, the wedge could slip low enough into the cavity to make removal difficult. One wedge was positioned on the downstream side of the signpost and the other wedge was positioned on the shoulder side of the signpost. These positions were chosen because it was believed that the force of the impact during a "hit" would compress the wedges and aid in their removal. (Eventually, the final position for the wedges were chosen as "upstream & traffic-side") The wedges are not interchangeable because one has a special cutout so that it does not contact the interior tapered wall of the concrete footing. A 1" hole was drilled through the top portion of all wedges to provide a means of extracting the wedge during the signpost replacement procedure by using a long pickax, (already used and carried by sign crews) along with a block of wood for leverage.

### 3.2 Prototype footing characteristics

The prototype footings were 24" in diameter and 48" tall and weighed approximately 1600 lbs. This footing size was chosen to resist the forces due to wind loading on the face of the sign panel in all of the various soil conditions and climates that exist throughout the State. The design of the depth and diameter produces enough soil surface area to resist the wind loading and would prevent the anchor from rotating, causing a sign to lean. The wind loading also governed the depth of the wood within the concrete. The signpost embedment depth was designed to provide a sufficient moment arm reaction to the wind loads without resulting in premature signpost failures. The cavity extended 42" deep for both the 4" x 4" and the 4" x 6" models.

A 1½" tube runs between the bottom of the cavity and the bottom of the footing to allow for drainage and to allow an escape path for any trapped air during installation. Two 14" rebar hoops were placed in the fresh concrete at approximately 2" and 6" from the top surface to help keep the footing from cracking during impact. Two ¾" ferrule loop inserts were also placed in the fresh concrete during finishing as a means for hoisting the footing for transport and installation.

## 4. DYNAMIC TESTING OF THE PROTOTYPE

A series of knockdown tests were conducted to ensure that the footing would not fail (structurally) and would remain perpendicular after impact. The knockdown tests also aided in the evaluation of the wedge design and material used.

### 4.1 Installation of the prototype

District 3, Special Crews, traveled to the Caltrans Dynamic Test Facility in West Sacramento to auger the large holes necessary to install the 24" diameter prototype footing. Two weeks later, a different boom truck was used by the Lab-staff to transport and install the footings into these previously drilled holes. Each footing was lowered into place, a signpost placed in the cavity, the wedges installed, and the post held plumb while soil was backfilled and tamped into the annular space around the footing.

### 4.2 Knock-down testing of the prototype footing

Full-scale crash tests were not required or economically feasible during the prototype design stage or for the subsequent testing of the final design. (A more detailed explanation is covered in Section 11.7, but essentially, wood signposts in soil have already been tested under full-scale conditions). A series of signpost knock-down tests, see Figure 1, were needed to determine if the footing size was adequate to prevent movement, to check the performance of the selected plastic material used for wedge construction, and to evaluate the different taper profiles. Maintenance personnel from Districts 3 and 4 participated in the tests in order to get their input for design improvements. Many of the same tests were repeated the following week for members of District 10 who were unable to attend the first session.

The tests consisted of hitting the posts approximately 18 inches above grade with a 203.2 mm x 152.4 mm x 8 mm thick wall, structural steel tube, 3.0 meters long. The tube was attached to the back of an 11,770 kg truck and cantilevered 1.57 meters out on the drivers side. The tube used a shear pin located 1.37 meters from the pivot point on the passenger-side end of the tube, see Figure 1, as a safety device to prevent damage to the tube or vehicle during a severe impact. On October 29, 1996, a number of different post configurations were hit using this vehicle, mounted tube, see Appendix D. A speed trap and set of tape switches were used during the knockdown tests to accurately determine the vehicle speed at impact.


Figure 1. Dynamic knockdown testing of the prototype Quick Change Sign Post footing with a G84 EXIT sign mounted on a 4" x 6" wood signpost with break-away holes. Vehicle speed is 22 mph.

## 4.3 Knock-down and removal under wet conditions

Some of the signposts and footings were soaked with water from an irrigation system for one week prior to the knock down tests. This test was done to simulate conditions, which might allow the entire footing to move.

After these posts were knocked down, they were soaked for an additional week to determine if the freshly broken signpost stub would swell to a point where wedge removal becomes difficult or impossible. This would cause the sign crew to remain on the scene for a longer period-of-time, defeating the rapid replacement objective.

## 4.4 Results of the knockdown tests on the prototype footing

One of the sign crews was instructed on how to install a new signpost and wedges into the footing. This signpost was then hit with the truck and beam and the same crew was allowed to conduct the removal and replacement (R&R). There were some difficulties in removing the wedges because; 1) they had hammered them into place more than what was necessary and 2) the pry bar they were using was too flexible and was hitting the ground before loosening the wedges. An alternate method was developed for wedge removal using a pickax and a 2 lb. sledgehammer. The pointed end of the pickax was inserted into the hole in the wedge and the handle was then rocked toward the signpost. The head of the sledgehammer was then placed between the pickax and the top surface of the concrete footing for leverage. The handle of the pickax was then pulled away from the signpost while the crewmember stepped down on the blade side of the pickax. These wedges still had to be knocked side-to-side with another small sledgehammer to finally work them loose. For the subsequent tests, the crews were instructed to not hammer the wedges in place and that only light taping or just foot pressure, was enough to keep the signpost secure. When installed in this manner, the wedges were easily removed using the pickax and hammer method.

It was discovered as part of these first knock down tests that the wedge on the downstream side was being bent-over as the signpost was being broken and raked over the top of it. It took several hits for the wedge to become damaged. It was also noted that none of the footings showed signs of movement, which indicated that a smaller (lighter) footing could possibly be used.

# 5. DESIGN CHANGES

As a result, from the knockdown tests performed on the prototype footing, several design changes were considered and used in the final design. The wedges were moved from downstream & shoulder-side to upstream & traffic-side, the wedge profile and depth were altered, and footing diameter was decreased from 24” to 18”. The wedges were moved because it was felt that the compression during impact was not aiding in their removal and moving them would prevent the wedges from being deformed during impact.

The wedge with the taper profile of 2.5” over 12” of length (11.8°) did not seem to have enough length or ability to secure the signpost. The wedge with the taper profile of 1.5” over 18” of length (4.8°) had an undesirable amount of vertical movement for the possible range of signpost dimensional variations. A tapered profile of 3.0” over 21.3” of length (8°) was selected because the vertical movement would be minimized while still allowing a fair amount of clamping force between the concrete and wood. These dimensions also make fabrication easier, see drawings in Appendix A.

# 6. CONSTRUCTION TECHNIQUES AND PROBLEMS

## 6.1 Test facilities

All fabrication and testing for this research project was conducted by Caltrans personnel at the Transportation Laboratory located in Sacramento, California. The knockdown tests were conducted at the Caltrans Dynamic Test Facility located at the California Highway Patrol Academy in West Sacramento, California.

## 6.2 Prototype design – right-side up

The first concrete footing prototype was constructed using a wooden form (to produce the cavity), which was placed inside a cylindrical cardboard form. The wooden form was made by assembling specially shaped pieces of ¾" plywood over a planed down 4" x 4" post. The plywood pieces were arranged to create the desired wedge shape at both the bottom and top of the cavity. A drain tube was attached to the bottom of this wooden form which was then placed on a 24" x 24" piece of plywood. The cylindrical cardboard form was placed over the top of the wooden form and wires were used to hold the forms in place within the cardboard tube. The wooden form had a 24" long extension from its top that was used to make sure it was plumb within the cardboard form. Concrete was then placed in the cardboard form to its topmost edge at which time it was vibrated, screeded, and finished. During this operation 2 rebar hoops 14" in diameter and 2 ferrule loop inserts were placed near the top surface of the finished concrete to provide strength and to aid in movement and placement of the finished footing. All footings cast this way were considered "right side up" because they were cast in the same orientation-as they would be when installed in the field. This method proved to be labor intensive and presented many problems. The wood forms could not be anchored well to the bottom plywood surface and actually were just resting on the drain tube-which fit into a recess cut in the bottom of the form. When the form was vibrated, one of the 4" x 4" wood forms began to float up and out of the concrete. This method also required time to install the rebar hoops, the ferrule loop inserts, and to finish the top surface of the concrete around the protruding form. This construction method allows removal of the wood forms after only 3 hours, but even after such a short period-of-time, removal was sometimes difficult and always unpredictable. The 4" x 4" forms usually came out easily but the 4" x 6" forms were always difficult to remove and often spalled the top surface of the footing when they finally did come out. The use of right side up wooden forms for footing construction is not recommended.

## 6.3 Final design – upside down

The final casting method used steel forms (rather than wood) to produce the cavity and the same cylindrical cardboard form to shape the exterior of the footing. It was vastly different from the prototype construction method in that the entire footing formwork is assembled upside-down. This method greatly reduced the amount of time needed to fabricate the footings as well as increased the integrity and quality of the footings.

Twelve steel forms were fabricated to produce the cavity, 10 each of the 4" x 6" signposts and 2 each of the 4" x 4" signposts. These forms did not have the same extension as the wooden forms to ensure the form was plumb with the cardboard form. To ensure perpendicularity they were bolted upside-down to a 24" x 24" x ¼" thick steel plate, see Figure 2.

The steel cavity form was offset from the center of the cardboard tube to provide a thicker concrete "wall" between the cavity and the outside of the footing on the downstream and shoulder sides. A small bead of silicone was applied at the joint between the cavity form and the crown plate to prevent spalling when the form is removed. The crown plate center was bowed approximately ½" lower than its sides. This produced a ½" high crown on the finished footing which would help prevent pooling of rain water around the base of the signpost and thus help reduce the possibility of swelling of the signpost. Two #5 rebar hoops were welded to two 6" long pieces of #5 rebar and two ¾" ferrule loop inserts. The insert mounting plugs were then used to secure the hoops and inserts to the steel crown plate. This method removed the need for placing these items into the fresh concrete and also allowed for better control over proper placement, see Figure 3.

Figure 2.
Typical 4" x 6" steel cavity form bolted to the steel crown plate. Note the drain tube and special nut used to hold it in place.

Figure 3. Rebar hoops welded together and to the ¾” ferrule loop inserts. The inserts are attached to the steel crown plate with sheet metal screws threaded into the plastic plugs that are normally used to attach ferrule loop inserts to wooden formwork.

A length of 1½” schedule 40 PVC pipe was attached to the steel form to produce a drain tube between the bottom of the cavity and the bottom of the finished footing. The drain tube was secured to the bottom of the steel forms with a piece of threaded rod, which screwed directly into the form. The other end of the drain tube was capped with a specially made “nut” that screwed onto the threaded rod.

This “nut” sealed the end of the drain tube to prevent fresh concrete from flowing down into the drain tube during fabrication. Small angle brackets were bolted to the steel crown plate and sheet metal screws were screwed directly into the cardboard form to hold it in place. The entire inside of the cardboard tube, as well as the steel cavity form, was coated with form release oil prior to placing the concrete. The concrete was then placed directly into the cardboard tube, vibrated, and screeded. No finishing work was required on what will eventually be the bottom of the footing. After the concrete had cured for 24 hours, the entire assembly was grasped with a forklift, mounted fixture and rotated “right side up”, see Figure 4.

Figure 4. Rotating a footing “right side up” 24 hours after casting to remove the steel cavity formwork.

The cardboard tube was left in place for several days to retain water, which produces concrete with a higher early strength. A small hydraulic jack was then used to remove the steel form from out of the green concrete, see Figure 5.

Figure 5. Removal of the steel cavity form using a small hydraulic jack.

This construction method was much easier and quicker than the "right side up" method used for the prototype construction. Mass production of these footings would probably involve fabrication techniques that would be an improvement over the ones used to produce the small number of footings needed for this project.

## 7. DYNAMIC TESTING OF THE FINAL DESIGN

### 7.1 Short term testing

These second generation designs were tested in a manner similar to the early prototype designs. Each was hit several times using the same truck-mounted beam at a low speed of 22 mph and at a higher speed of approximately 40 mph. In addition to the conventional, knockdown tests, several unconventional knockdown tests were done. These other tests involved hitting a 4" x 6" signpost, which did not have the breakaway holes drilled through them. This was done to be sure the footing did not move or break in the event the sign crew inadvertently forgot to drill these holes. In all instances, the broken stub was easily removed and replaced with a new signpost in less than 10 minutes. None of the footings moved during these tests and none were cracked or otherwise broken.

### 7.2 Long term testing

In order to evaluate the long-term effects of wind loading and sun exposure (on the wedges), three of these footings were left in place at the Caltrans Dynamic Test Facility in West Sacramento. In 1999, after 2 years of exposure, the footings remained plumb and the wedges were easily removed. The top of the wedges, were slightly discolored (when compared to the portion of the wedge that was inside the footing and thus protected from solar exposure) but were not adversely affected and could remain in service.

## 8. INITIAL INSTALLATION AND BROKEN SIGNPOST REPLACEMENT PROCEDURES

The following lists describe the procedures involved with both an initial installation of this quick-change signpost system and the removal and replacement of a signpost after it has been downed by an errant vehicle. For both procedures it is very important that sign crew personnel understand the wedges DO NOT have to be hammered in tightly. Evaluation of footings left in place for long periods indicate that the wedges are heavy enough that they will not work themselves out. They will actually work their way in tighter as the signpost is vibrated by the wind. If the wedges are hammered in tightly and the wood later swells, due to moisture, the wedges may become difficult to remove.

### 8.1 Initial installation procedure

The following list is a "step-by-step" installation sequence that should be given to sign crew personnel along with the footings. These steps should be reviewed and understood by all personnel before leaving the yard. A few days prior to installation, the site needs to be marked and cleared for digging by calling UNDERGROUND SERVICE ALERT at (800) 642-2444.
Appendix C contains the same list in a format that can be given directly to sign maintenance crews prior to installation of a quick-change signpost footing.

1. Position and level the auger truck.
2. Use an 18" (minimum) or a 24" (maximum) auger bit, see Figure 6. The larger bit (24") will make tamping around the installed footing easier.

Figure 6. Augering a 24" diameter hole for initial installation of a quick-change signpost footing. Note that the crew is scattering some of the excess native soil during the augering operation.

3. Ensure the auger is plumb before starting and during the auguring operation.
4. Drill the hole to a depth of 54".
5. Using ¾"crushed gravel, backfill the hole to a depth of 48." The backfill can be 47" to allow for settling of the footing, but it cannot be more than 48" or the footing will be below grade. The gravel is to aid in drainage.
6. Roll or otherwise store the auger bit.
7. Insert the shouldered ¾" eyebolts into the ferrule loop inserts and screw both of them down until the shoulder firmly contacts either the concrete surface or the washer, if used. Run an appropriate lifting chain (rated for a minimum working load of 2000 lbs.) through the eyebolts and secure it to the boom hook.
8. Carefully lift the footing to vertical and adjust the chain as needed to ensure the footing will hang plumb from the boom cable. Position it over the hole.
9. Lower the footing into the hole taking care not to knock an excessive amount of native soil into the hole, see Figure 7. Before the footing is lowered completely, make sure the embossed arrow on the top surface of the footing is pointing in the same direction as traffic flow. This is to ensure proper orientation of the wedges.

Figure 7. Lowering the footing into the augered hole.

10. Completely lower the footing, disconnect the chain, and move the boom away.

11. Remove the eyebolts from the footing. Place grease into the threaded ferrule loop insert holes and reinstall the plastic plugs. Be sure this is done prior to beginning to fill the hole or soil will fill these threaded holes.
12. Place a quality, full-size post into the cavity and lightly place the wedges in their corresponding locations, see Figure 8.

Figure 8.
Footing, in place, ready to be backfilled. Note that the signpost and wedges are installed before any backfilling is done.

The wider wedge with the "dog-leg" cut goes on the upstream side. For both wedges, look at the top of the wedge and determine which side has a 90° angle between its top and one of the wider sides, (the other angle will be about 82°), see Fiqure 9.

Fiqure 9.
The side with the 90° angle goes against the wood post.

13. Check that the footing is close to plumb and that it is properly oriented with the traveled way.
14. Using a (torpedo) level, have one person hold the post/footing plumb, (a slight tilt toward oncoming traffic may be desirable), while another uses native soil to backfill around the footing and tamp it down. This should be done in approximately 8” lifts, see Figure 10.
15. Once satisfied that the footing is properly and securely installed, lightly hammer the wedges down or merely step on them with full body weight to seat them. DO NOT USE EXCESSIVE FORCE OR A LARGE NUMBER OF HAMMER BLOWS. (This is unnecessary and will only make removal difficult)
16. Spread the unused native soil in a manner that will not pose a threat to motorists. Do not leave it piled at the installation site, see Figure 11.

Figure 10.
Final backfilling and tamping. (Looking in the direction of traffic flow at a gore point)

Figure 11. Footing installation completed.

**8.2 Broken signpost replacement procedure**

The following list is the "step-by-step" procedures, for removal & replacement (R&R) of a broken signpost. This list should be given to sign crew personnel along with the footings. These steps should be reviewed and understood by all personnel before leaving the yard. Appendix C contains the same list in a format that can be given directly to sign maintenance crews prior to conducting a broken signpost removal and replacement.

1. Clear broken post debris from around the footing, see Figure 12.

Figure 12.
Typical result after a 4" x 6" signpost is impacted by an errant vehicle. Wedges are installed on the upstream side and the traffic-side.

2. Place the pointed end of the pickax fully into the hole in one of the wedges. See Figure 13.

Figure 13.
Common pickax being used to remove the wedges.

3. Tilt the pickax handle

toward the center of the footing to allow placement of a 2 lb. sledgehammer head, (or other spacer material), between the head of the pickax and the top concrete surface of the footing. This is to provide leverage, see Figure 14.

Figure 14.
Sledgehammer being used for leverage.

4. Grasp the end of the pickax handle and pull away from the center of the footing while placing downward pressure on the flat end of the pickax with either foot. You may have to fully stand on the flat end of the pickax, see Figure 15.

Figure 15.
Step on the flat blade of the pickax while pulling the handle toward you.

5. The wedge should pull free, sometimes suddenly.
6. If the wedge does not come loose easily, use another hammer to strike the sides of the wedge to help work it loose.
7. Again, apply pressure with the pickax. If the wedge does not come loose, you may have to strike the sides with one hammer while applying pressure with the pickax.
8. If the wedges cannot be removed using a pickax, use a hex bar and a piece of the broken post (for leverage) to remove the wedges using the same holes as above.
9. Once loose, remove the wedges and set aside. They will be re-used.
10. Grasp the broken stub with gloved hands and wiggle it until loose. Remove the broken stub from the cavity, see Figure 16.

Figure 16. Broken signpost stub, being removed from the footing after removal of the wedges.

11. Make sure the cavity is fairly, clear of foreign material.
12. Place the new signpost into the cavity and let it fall all the way to the bottom. Place the wedges in their corresponding locations. The wider wedge with the "dog-leg" cut goes on the upstream side. For both wedges, look at the top of the wedge and determine which side has a 90° angle between it's top and one of the wider sides (the other angle will be about 82°). The side with the 90° angle goes against the wood post.
13. Once satisfied that the post is properly placed, lightly hammer the wedges down or merely step on them with full body weight to seat them. DO NOT USE EXCESSIVE FORCE OR A LARGE NUMBER OF HAMMER BLOWS. (This is unnecessary and will only make removal difficult)

## 9. FIELD EVALUATIONS AND RESULTS

All of the testing done at the Caltrans Dynamic Test Facility only simulated real world conditions and was used to aid in the design and development of this system. The only way to determine the true usefulness of this system was to evaluate it under field conditions. For this reason, an evaluation period was planned and approved by the Caltrans Chief of Traffic Operations, Mr. James Borden (see Appendix F). The evaluation would answer questions such as:

1. Will debris be blown into the footing by traffic-induced and natural winds?
2. Is the drain hole necessary or does it just allow ground water to flow upward into the cavity?
3. Will the wedges swell in wet locations and become difficult to remove?

This evaluation period was also needed to allow sign crews a chance to use the footings and provide feedback on possible improvements to the design. A reporting form was developed to make it easy for the maintenance crews to report the results of knockdowns (see Appendix B). Districts 3 and 4 were selected because they are relatively close to the Lab location in Sacramento. In addition, District 1 was added after interest was expressed in this project.

### 9.1 Locations

Each of the three Districts involved in this evaluation period was contacted and asked to provide a list of sites that would be suitable for placing one of these quick-change signpost footings. Caltrans Office of Research staff then delivered the desired number of footings plus a few extras for future placement by the sign crews.

#### 9.1.1 District 1

Four 4” x 6” and two 4” x 4” footings were delivered to the Caltrans District 1 Maintenance yard in Eureka on November 17, 1997. On June 30, 1998 an additional 4” x 4” and 4” x 6” were delivered to the same Maintenance yard in Eureka. The principal investigator helped a sign crew install the first footing to make sure the crew understood how to install and use the other footings that were delivered. As of this writing, not all footings delivered to District 1 were immediately installed. Listed are some of the District 1 footing locations:

1. Hwy. 211- at post mile 78.58. A standard R1 “STOP” sign on a 4” x 4” signpost. (Installed on 11/18/97)
2. Hwy. 254- at post mile 43.37. A standard R1 “STOP” sign on a 4” x 4” signpost. (Installed on 12/11/97)
3. Hwy. 255- at post mile 2.00. A 48” x 48” R1 “STOP” sign on a 4” x 6” signpost. (Installed on 11/26/97)
4. Hwy. 101- at post mile 11.53. A R11 “DO NOT ENTER” and a R11A “WRONG WAY” signs; both on a 4” x 6” signpost. (Installed on 12/18/97)

On June 30, 1998, one 4” x 4” and three 4” x 6” footings were delivered to the District 1 Maintenance yard in Ukiah. These four footings were left with the maintenance personnel for future installations.

### 9.1.2 District 3

Four footings were installed in the greater Sacramento area on 12/2/97 at the following locations:

1. Westbound Hwy 50 at the Southbound Hwy 99 interchange. This is a W58 sign mounted on a 4” x 6” signpost with breakaway holes.
2. At the split of Eastbound Interstate 80 and Hwy 51 (Capitol City Freeway). This is approximately ¼ mile from the east end of the Blecher-Freeman Memorial causeway. This is a W58 sign mounted on a 4” x 6” signpost with breakaway holes.
3. Eastbound Hwy 51 (Capitol City Freeway) at the Marconi Ave. off ramp. This is a G84 “EXIT” sign, mounted on a 4” x 6” signpost with breakaway holes.
4. Westbound Hwy 51 (Capitol City Freeway) at the Marconi Ave. off ramp. This is a G84 “EXIT” sign, mounted on a 4” x 6” signpost with breakaway holes.

### 9.1.3 District 4

Two 4” x 6” and two 4” x 4” footings were delivered to the Caltrans District 4 Maintenance yard in Oakland on March 30, 1998. The next day the principal investigator, helped the sign crew install several footings to make sure they understood how to install and use the other footings that were delivered. These footings were installed at the following locations:

1. Northbound 880 at the $29^{th}$ Ave. off ramp. A Standard R1 “STOP” Sign, on a 4” x 4” signpost. (Installed on 4/1/98)
2. Northbound 880 at the $29^{th}$ Ave. off ramp. A R11/R11A sign, on a 4” x 6” signpost. (Installed on 4/1/98)
3. Eastbound Hwy. 24-at the Pleasant Hill off ramp. A W4 sign, on a 4” x 6” signpost. (Installed on 4/1/98)
4. Eastbound Hwy. 24-at the Pleasant Hill off ramp. A W81 sign, on a 4” x 4” sign post. (Installed on 4/1/98)

On April 2, 1998 the principal investigator delivered two 4” x 6” footings to the Caltrans District 4 Maintenance yard in Gilroy and helped the sign crews install them at the following locations:

5. Eastbound Hwy. 152- at the Hwy. 156- junction. A W60 MERGE Sign, on a 4” x 6” signpost. (Installed on 4/1/98)
6. Westbound Hwy. 152- at post mile 34.2. A W29 “SPEED LIMIT ” Sign, on a 4” x 6” signpost. (Installed on 4/1/98) This one was installed to check for wind-load induced footing movement.

At the request of a sign crew lead worker, on May 4, 1999 an additional six 4” x 6” footings were delivered to the same Maintenance yard in Gilroy for future use. These last six footings were installed at the following locations:

7. Santa Clara 880 at post mile 4.0. S/B 880 to S/B 101 circle ramp. A 72” x 72” W4 (90 degree arrow) on a 4” x 6” signpost.
8. Santa Clara 880 at post mile 4.0. S/B 880 to S/B 101 circle ramp. A 72” x 72” W4 (90 degree arrow) on a 4” x 6” signpost.
9. Santa Clara 880 at post mile 4.0. S/B 880 to S/B 101 circle ramp. A G84 “EXIT” sign on a 4” x 6” signpost.
10. Santa Clara 152 at post mile 12.8, junction of S/B Ferguson Road and E/B 152.

A G8 (text and arrow combination) on a 4” x 6” signpost.

11. Santa Clara 152 at post mile 12.8, junction of S/B Ferguson Road and E/B 152.
    A G8 (text and arrow combination) on a 4” x 6” signpost.
12. Not yet installed.

### 9.1.4 District 11

The San Diego County contracted the removal and installation of 221 existing signs by replacing them with the Quick Change Sign Post system at various locations on Rout 5 from the US-Mexican border to the end of the County and on Route 8 from Nimitz Boulevard to the Imperial County line. All signs were on a 4x6 wooden post.

A few changes to the footing design were made, such as, adding 2 more rebar hoops, hooking the ferrule loop through the rebar hoop instead of welding, having a total of 6 straight rebars equally spaced around the cavity, and several minor dimension changes mainly to compensate for a different footing manufacturing procedure. Most of the changes were to help strengthen the footing or make it easier to manufacture. The contract was awarded to TDS Engineering and the total project cost was $221,775.00. The project contract number was 11-244604.

One of the problems discovered during the installation phase was that the corner of the cavity where both flat sides meet had a beveled shaped corner, which pushed the wooden post out of plumb when it reached the bottom angled slope. It was determined that that particular corner must have a 90-degree corner for the wood post to seat properly. It was decided to cut the wooden post before it reached the bottom angled slope and secure it with the wedges. This procedure required 1 worker holding the wood post before the bottom angled slope, while another worker installed the wedges. After the contract was completed, there were some thoughts of getting another contractor to clean out the beveled corner to a 90-degree corner. The concern is that what once was a 1-person job now became a 2-person job. So far no action has taken place regarding this matter.

Also, from maintenance faxed reports, it was noted that compaction was not properly done. Several footings were knocked out of plumb from a knocked down sign due to improper compaction of the soil around the footing.

## 9.2 Reporting a hit – FAX Sheets

Each sign crew that were given footings, were also given a pre-printed sheet that could be filled out and faxed back to the Principal Investigator. These sheets, when received, were used to track the number of times a particular footing was hit and how easy, or difficult, it was for the sign crew to remove and replace the broken signpost. A blank copy of this form as well as copies of some of these completed sheets sent in by sign crews are included as Appendix B.

## 9.3 Results

Many of the replacement times listed on the sheets faxed in from sign crews have been within the desired 10 minute time frame, some as low as 4 minutes. There have been instances where the reported times were as long as 45 minutes. In those few cases, the appropriate sign crew was contacted to determine why it took more than 10 minutes to complete the broken signpost removal and replacement. In one case, the signpost was hit from the opposite direction, which resulted in a cracked footing, demolished wedges and left the footing out of plumb. In another instance, a footing in District 4 on Hwy. 24, at the Pleasant Hill off ramp, was hit twice within a three-week period and left out of plumb. This location was particularly muddy on the date of installation and proper compaction of the soil around the footing was virtually impossible.

Overall, the crew responses have been favorable and a limited number of requests for more footings continue to be received. Some sign crews would rather continue to place small signposts into augered holes in soil because they are familiar with that method of sign placement. Most crews feel this new signpost footing is a worthwhile improvement that will save time and reduce their exposure to traffic.

Even with large sign panels, wind loading has not caused any of the field installed footings to move. The footings installed and left at the Caltrans Dynamic Test Facility in West Sacramento did not experience any movement or damage due to wind loads.

## 10. CONCLUSIONS

When properly installed and used, this quick-change signpost system can greatly reduce the amount of time required to remove and replace a downed signpost. It is economically feasible for locations that experience a large number of hits. However, it is principally designed for locations that do not experience "wrong way" hits as this can damage the footing and wedges.

## 11. RECOMMENDATIONS

This section details the recommendations made, from the results of the work accomplished during creation of these footings and the ensuing field evaluation period.

### 11.1 Removal of all unnecessary signposts from the roadside

The main objective of this research project is to minimize the amount of time that Caltrans maintenance workers are exposed to hazardous traffic conditions. One of the best ways to accomplish this is to remove any or all, roadside signs, which are found to be unnecessary for the motoring public. This would include all "Adopt a Highway" signs and other highway "beautification" signs. Only those signs, which serve the motorist by providing information crucial to the navigation from one point to another, should be erected along or near the roadside.

### 11.2 Only financially reasonable for "high hit" locations (5-6 per year)

Each footing cost approximately $100 to build and another $91 to install, see details in Appendix E. However, the removal and replacement of a signpost installed in one of these footings costs is approximately $32 cheaper than the same R&R of a signpost in soil. Therefore, it will take six hits for the $32 savings to pay for the $191 initial installation cost.

### 11.3 Extended trial period

The footings that were placed in the field for the evaluation period should remain in place for at least another year to continue to gather data on ease of replacement. Some of the footings should be installed in the Los Angeles area, District 7, where they are more likely to be hit.

### 11.4 Make maintenance crews aware of the product

All 12 of the districts within Caltrans should be made aware of these footings by either a direct memo or through an article in the Caltrans periodical "GOING PLACES". This will help increase awareness of the product and will hopefully, generate requests for it. Maintenance crews are reluctant to switch away from a method of signpost replacement that they have become familiar with over many years. They especially do not like to have such a change forced upon them and acceptance of a product, like these footings, is more likely to take hold if it is offered to them as an alternative.

A videotape was produced, as part of this project, as a start toward making sign crews aware of these footings. Show them how to install them, and how to do a signpost replacement. A more in depth video describing installation steps, removal & replacement, and an accompanying brochure should be made and distributed to sign maintenance crews.

### 11.5 Loan the formwork to Districts and provide instruction on how to make the footings

During the early phase of this project, manufacturing a large number of footings here in Sacramento for shipment to remote districts would be cost prohibitive due to the transportation costs. The best way to get footings to districts far from Sacramento would be to ship the necessary formwork and fabrication instructions to the districts and let them manufacture them using local concrete sources. If these footings gain widespread acceptance and a large number of requests are received, a plan should be in place to have them manufactured by an outside vendor that specializes in pre-cast concrete structures. It would also be preferable to have a vendor that has locations in both Northern and Southern California.

### 11.6 Determine if a patent should be pursued

This is the first footing, which continues to use wood signposts and as such, its design should be reviewed by Caltrans attorneys for possible patent rights. This step should be taken only to protect Caltrans from eventually having to pay high costs to buy a product that was originally developed by Caltrans. It is not necessarily intended as a vehicle to produce income from royalties or licensing.

### 11.7 Stamp the wedges for ease of installation

One of the suggestions offered by a sign maintenance crew was to stamp the top of the wedge with an arrow that depicts the direction of traffic flow. This would ensure that the wedges are properly placed within the footing. While the wedges have been incorrectly installed by sign crews, (and they still hold the signpost in place when this is done) it is best if they are installed as intended in the original design.

## 12. IMPLEMENTATION

The New Technology & Research Program, Office of Infrastructure Research will continue to distribute the remaining footings that have already been fabricated and will continue to increase awareness of the footings. If necessary, more footings may be cast here in Sacramento until interest reaches a level where this approach becomes impractical. A draft Standard Special Provision (SSP) will be completed and submitted so that these footings may be specified in new construction projects. If interest in these footing seems to be steadily increasing, then a plan should be developed for having them mass produced and distributed by an outside vendor.

The Division of Highway Maintenance will select appropriate installation sites, train sign crews in correct installation techniques, monitor footing performance, and report their findings to the Office of Infrastructure Research. If the program is successful, the Division of Highway

Maintenance will arrange to have concrete foundations and wedges fabricated and stocked for distribution to Caltrans sign maintenance crews. They will also instruct Caltrans sign maintenance crews on the proper installation of the reusable concrete foundations.

## 13. FUTURE RESEARCH OR DESIGN CHANGES

One of the recommendations listed above was to continue the evaluation period. This was made because the Principal Investigator realizes there may be room for improvement in this product. This section lists some of the possible design improvements that may be investigated and/or implemented.

### 13.1 Make one size footing for both size signposts

There are currently two different types of footings, one for a 4” x 4” signpost and one for a 4” x 6” signpost. It would make fabrication, handling, and transportation much easier if there was only one type of footing for both of these very common sizes of signposts. One way to accomplish this is to make only the footing for the 4” x 6” signpost and use a 2” x 4” board as a “back-up” for the 4” x 4” signpost. This board would make the 4” x 6” signpost dimensionally the same as the 4” x 6” signpost, and the wedge systems would hold this signpost the same as if it were a 4”x 6” signpost. This approach is currently being tested at one of the locations in the Gilroy area of District 4.

### 13.2 Larger diameter (20”) footing for locations where reverse hits are possible/likely

One of the footings installed in the Eureka area of District 1 was broken when it was hit from the opposite direction. These footings were designed to be use primarily in gore areas where reverse direction hits are not likely to occur. The footings are designed with the signpost cavity offset toward the upstream side and toward the traffic lane side of the footing. This was done to provide a thicker wall between the cavity and the outside of the footing on the sides that will bear the greatest force during an impact. This leaves the upstream and traveled way side somewhat thin and unable to take the same forces. One way to help alleviate this problem is to increase the diameter of the footing from 18” to 20” for use in locations where reverse direction hits are likely. This should not be done to all footings as this would result in higher costs for footings that may never be hit from the wrong direction.

## 14. REFERENCES

1. Safety Information Management System (SIMS) database into which all Caltrans injury accidents and motor vehicle accidents are entered, 2000. Contact the Caltrans Administrative Service Center, Office of Safety and Health at (916) 227-2682 for more information. Website address is http://www.dot.ca.gov/hq/paffairs/about/safety.htm.

## 15. APPENDICES

A CAD drawings of the Footings, Wedges, & Truck-Mounted Beam

B Blank copy and Summary of “Hit” Sheets

C Instruction sheets for initial Installation and Replacement

D List of Dynamic Tests

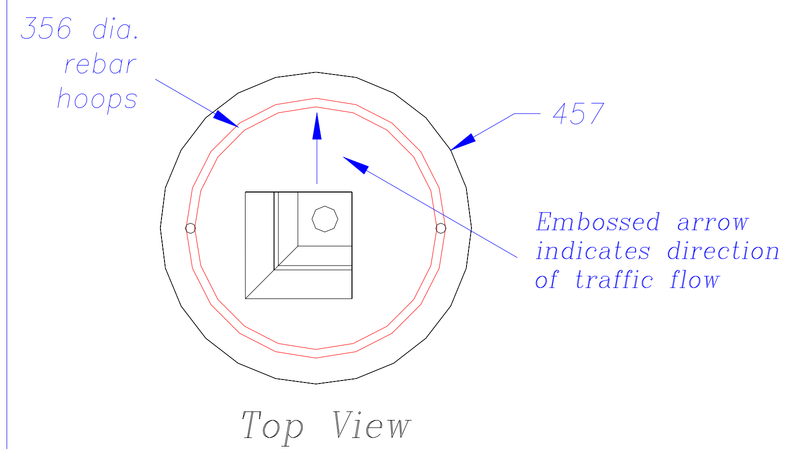
E Cost comparison of using this quick-change signpost system over the currently used system of placing signposts in augered holes in soil

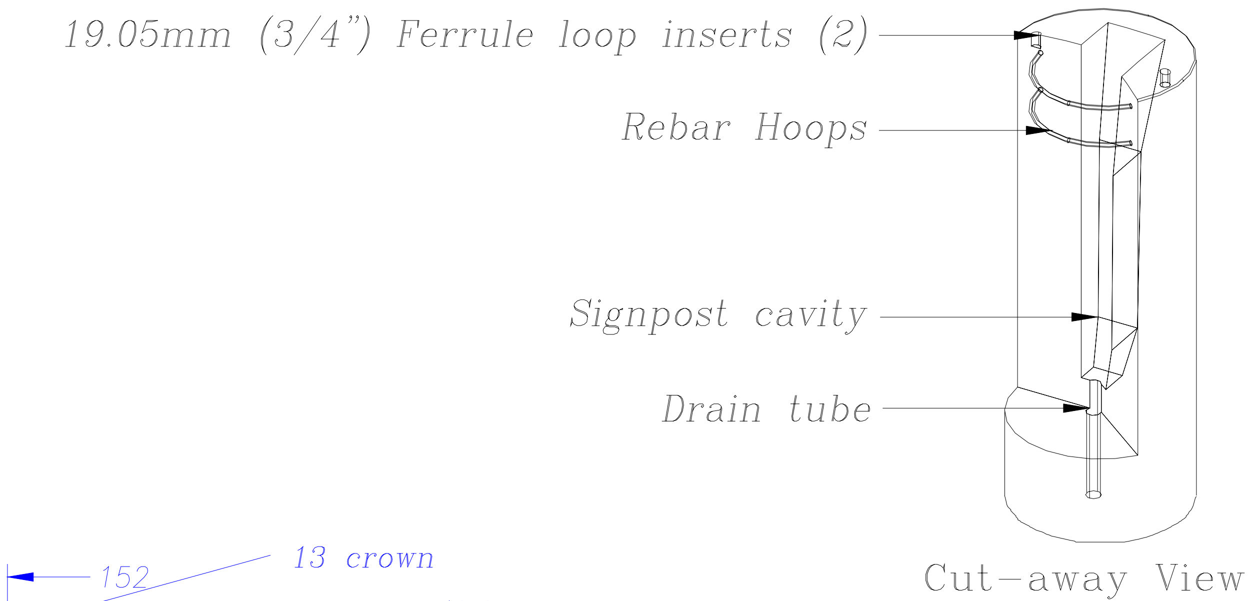
F Copy of Letter from: James Bourden granting experimental use.

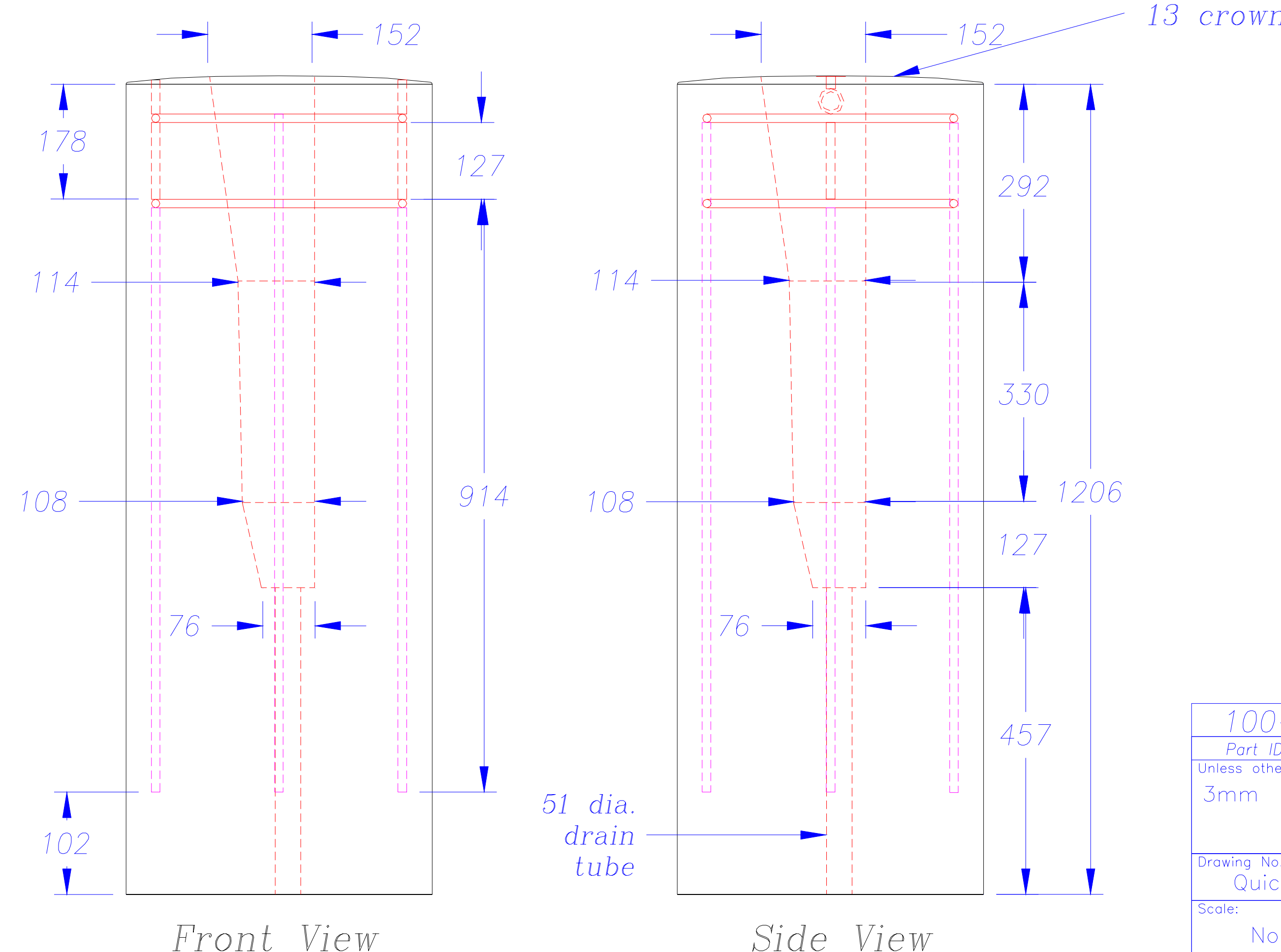
G SPECIAL PROVISIONS and Bid Summary

# Appendix A

## CAD drawings of the Footings, Wedges, & Truck-Mounted Beam



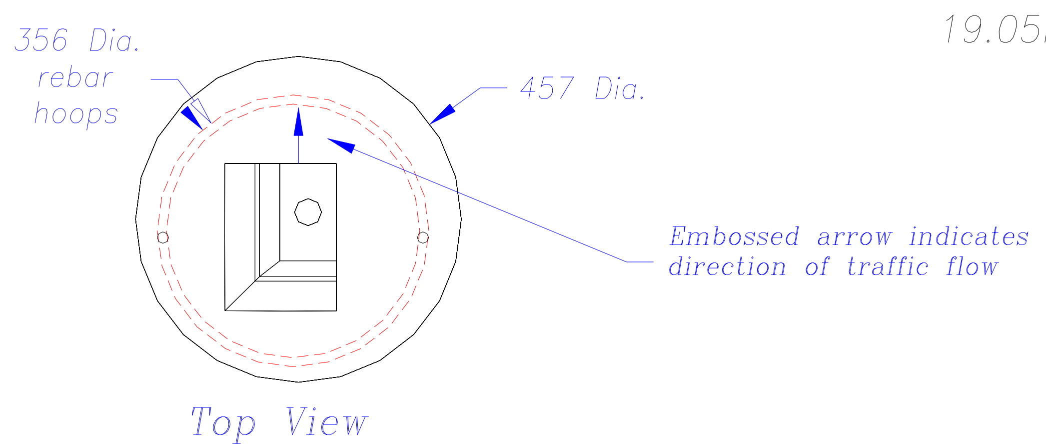



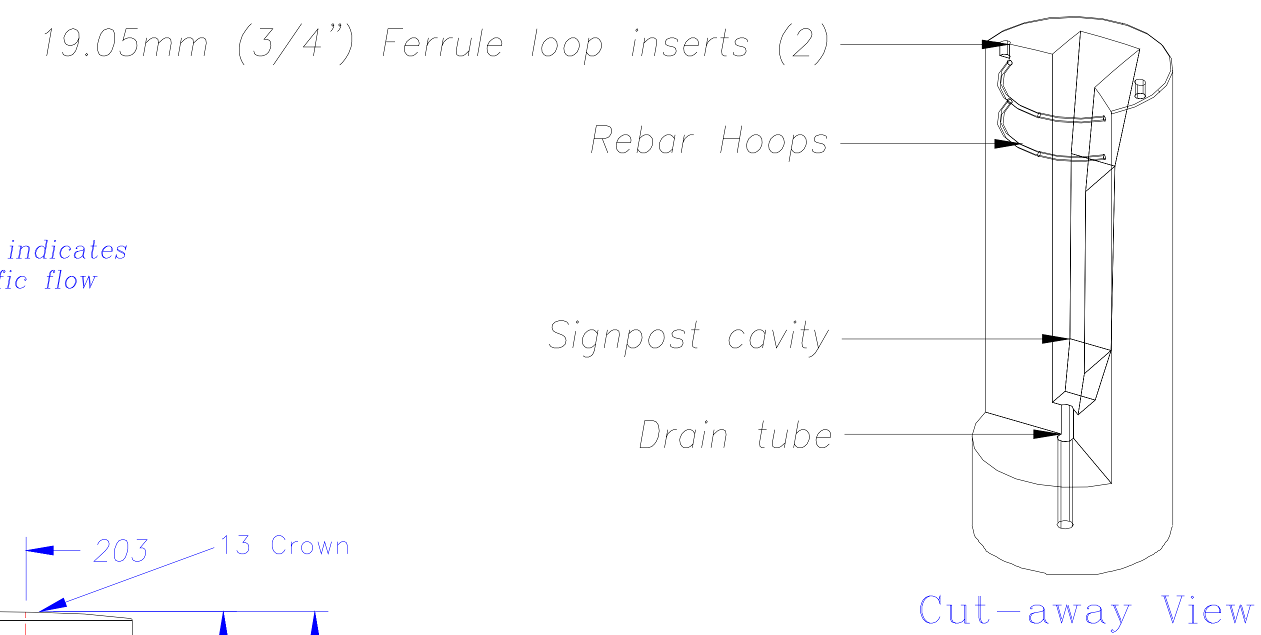



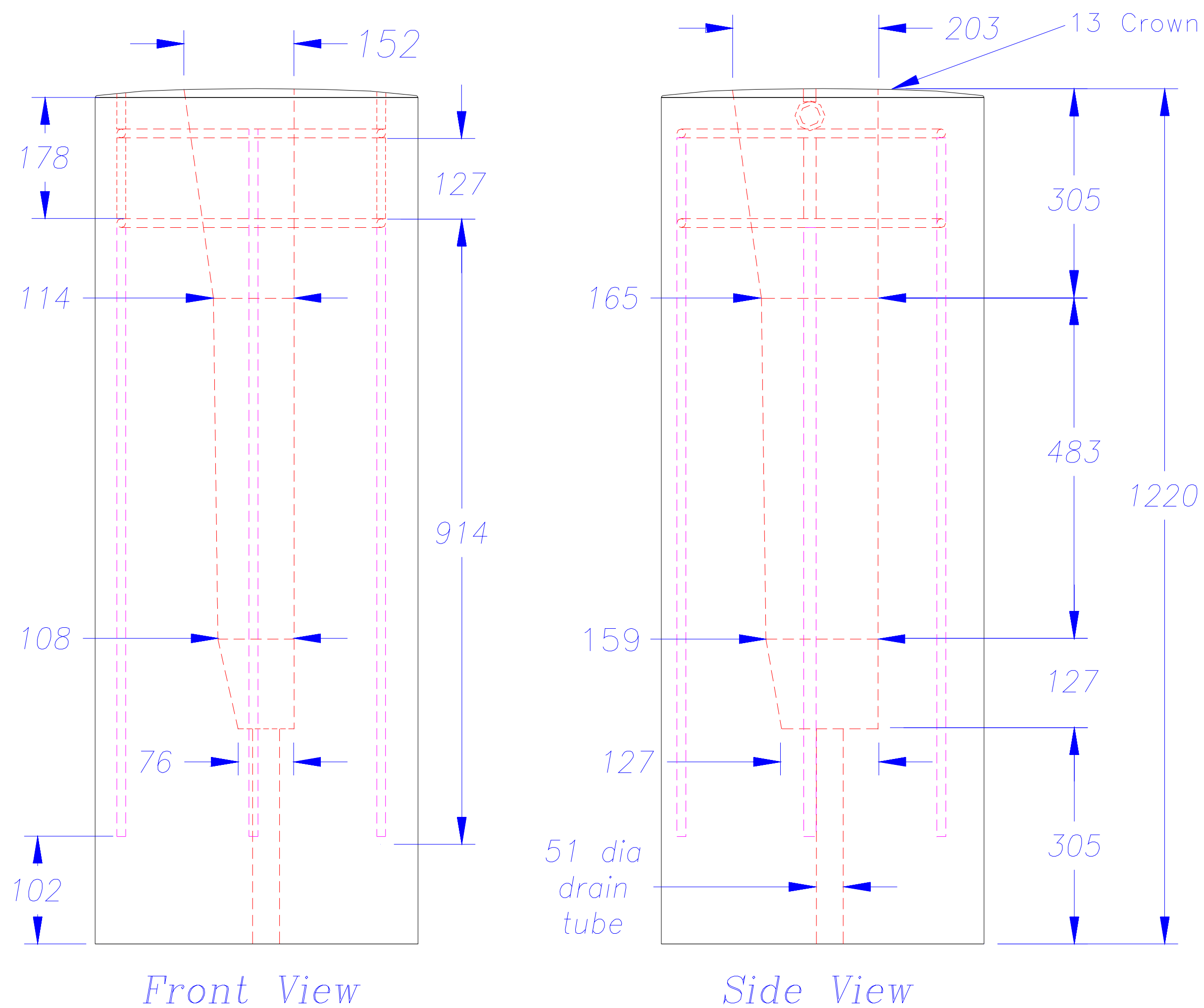

Notes:

1. Two ferrule loop inserts at 19.05mm (3/4")-10 UNC, are welded to the 356mm dia. rebar hoop assembly for hoisting.
2. Footing has a convex top surface, to aid run-off.
3. Cavity is offset from footing center 25mm upstream, and 25mm toward the travel way.
4. Concrete mix design, (per cubic meter):
   - 7 sacks (418kg) of portland cement Type II modified.
   - 981kg aggregate, 16mm max. dia.
   - 944kg sand.
   - 99L water.
   - slump approx. 102mm
5. All dimensions are in millimeters unless otherwise shown.

| Part ID No. | Quantity | Description | |
|---|---|---|---|
| 100-762 | 1 | Footing for 100mmx100mm wood post | |
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research | |
| Drawing No.: Quick Change Sign Post 1 | | Title: 100mm x 100mm Sign Post Footing | |
| Scale: None | File: 4x4final.dwg | Drawn by: Natane Clarke | Checked by: M. White |
| Size: A | Sheet 1 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-17-98, 5-5-00 | |



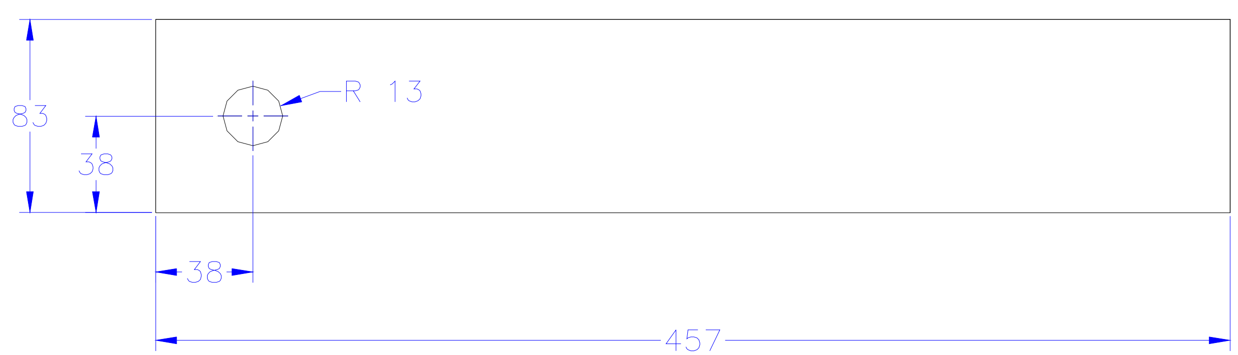




Notes:

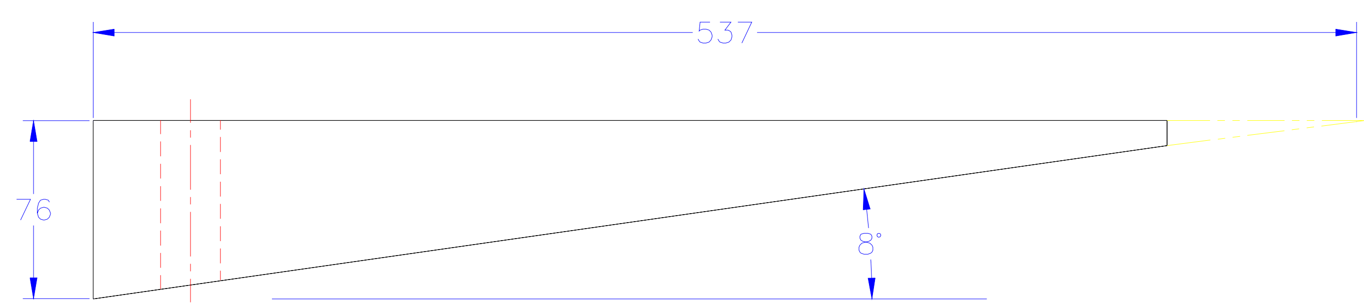
1. Two ferrule loop inserts at 19.05mm (3/4”)-10 UNC, are welded to the 356mm dia. rebar hoop for hoisting.
2. Footing has a convex top surface to aid run-off.
3. Cavity is offset 25mm upstream and 25mm toward the travel way from the footing center.
4. Conrete mix design, (per cubic meter):
   - 7 sacks (418kg) of portland cement type II modified.
   - 981kg aggregate, 9.53mm max. dia.
   - 944kg sand
   - 99L water
   - slump, approx. 102mm
5. All dimensions are in millimeters unless otherwise shown.

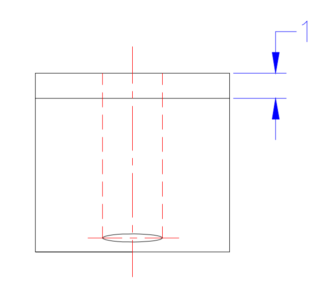
| | | |
|---|---|---|
| Part ID No.: 152-914 | Quantity: 1 | Description: Footing for 100 x 150 mm wood post |
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 2 | | Title: 100 x 150 mm Sign Post Footing |
| Scale: None | File: 4x6final.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 2 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-17-98, 5-10-00 |




Notes:

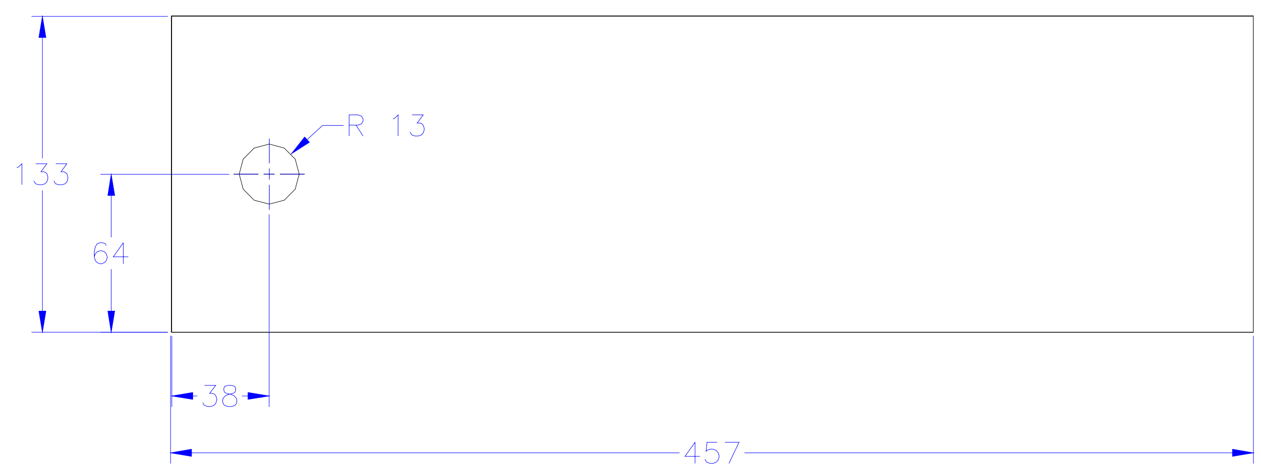
1. All dimensions are in millimeters unless otherwise shown.
2. Tan 8° = (76)/(537)
3. Phantom lines show section to be removed.



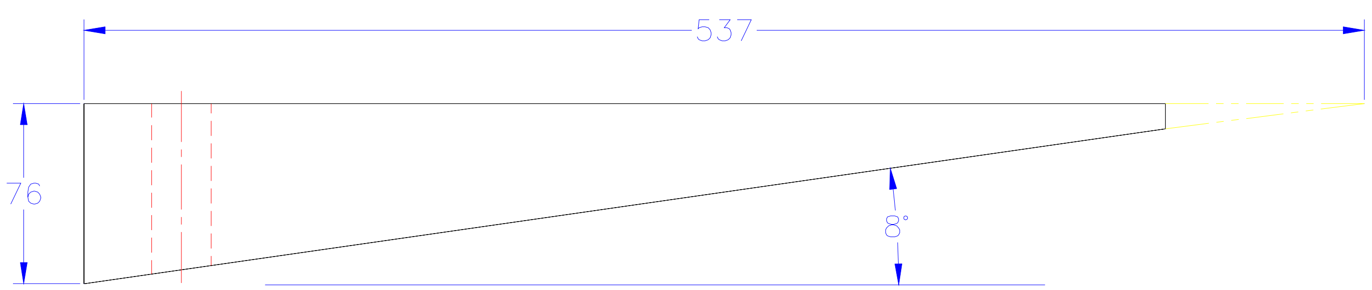

| Part ID No. | Quantity | Description |
|---|---|---|
| 100-W1 | 1 | Recycled carpet fiber wedge |

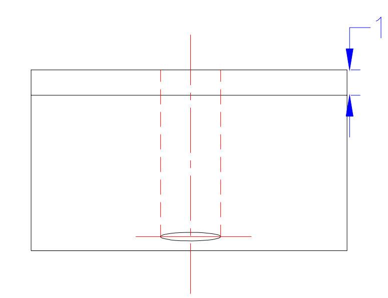
| | |
|---|---|
| Unless otherwise specified tolerances are: 3mm | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 3 | Title: Wedge for 100x100mm footing |
| Scale: None | File: 3wedge.dwg |
| Drawn by: Natane Clarke | Checked by: M. White |
| Size: A | Sheet 3 Of 13 |
| Revision Dates (Disregard Prints Bearing Earlier Revision Dates) | 7-17-98, 5-10-00 |




Notes:

1. All dimensions are in millimeters unless otherwise shown.
2. Tan 8° = (76)/(537)
3. Phantom lines show section to be removed.




| Part ID No. | Quantity | Description |
|---|---|---|
| 150-W1 | 1 | Recycled carpet fiber wedge |

Unless otherwise specified tolerances are: 3mm

STATE OF CALIFORNIA
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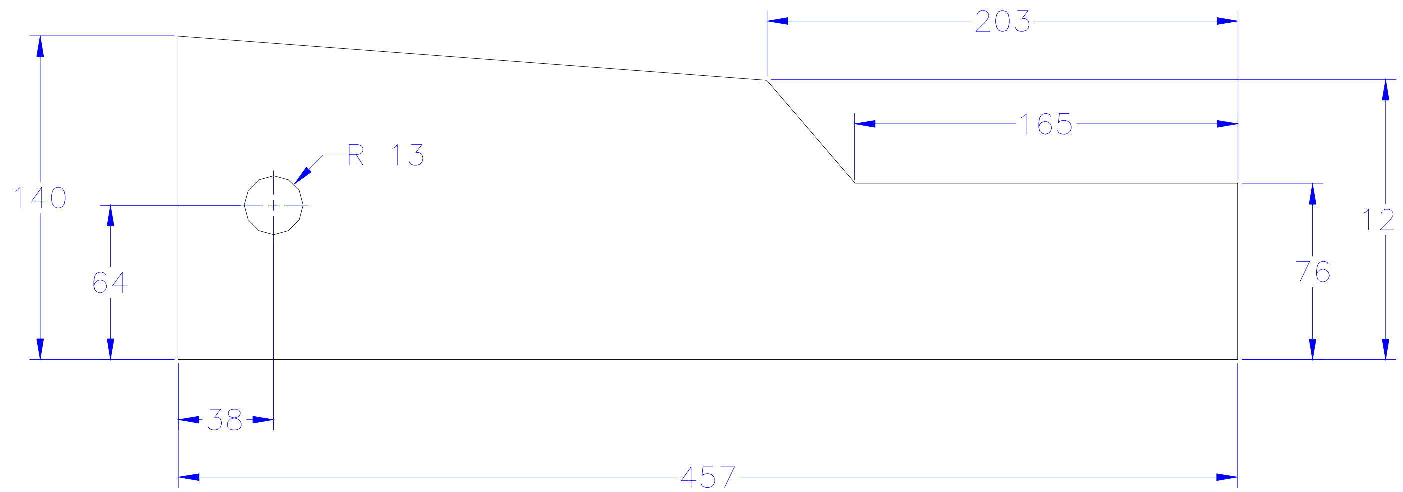
Office of Research

Drawing No.: Quick Change Sign Post 4

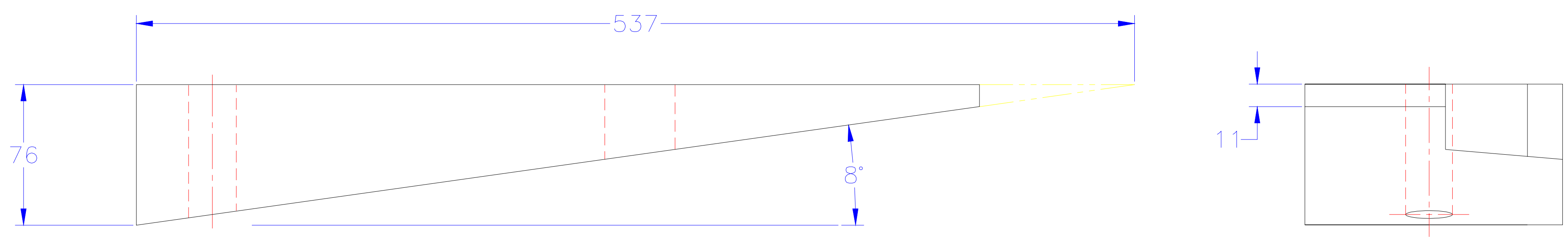
Title: Wedge for 150x100mm footing

| | | | |
|---|---|---|---|
| Scale: None | File: 5wedge.dwg | Drawn by: Natane Clarke | Checked by: M. White |
| Size: A | Sheet 4 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates) 7-17-98, 5-10-00 | |

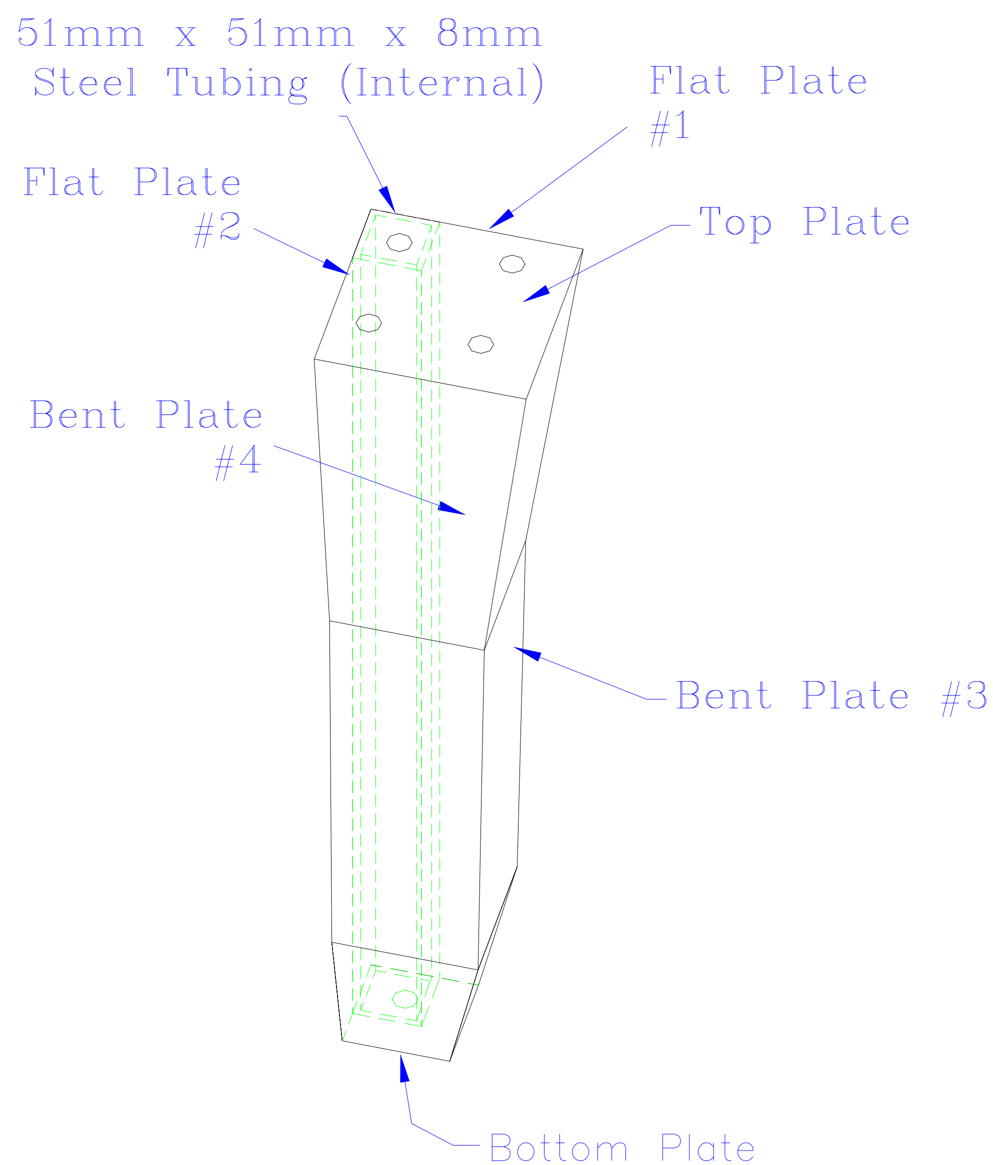



Notes:

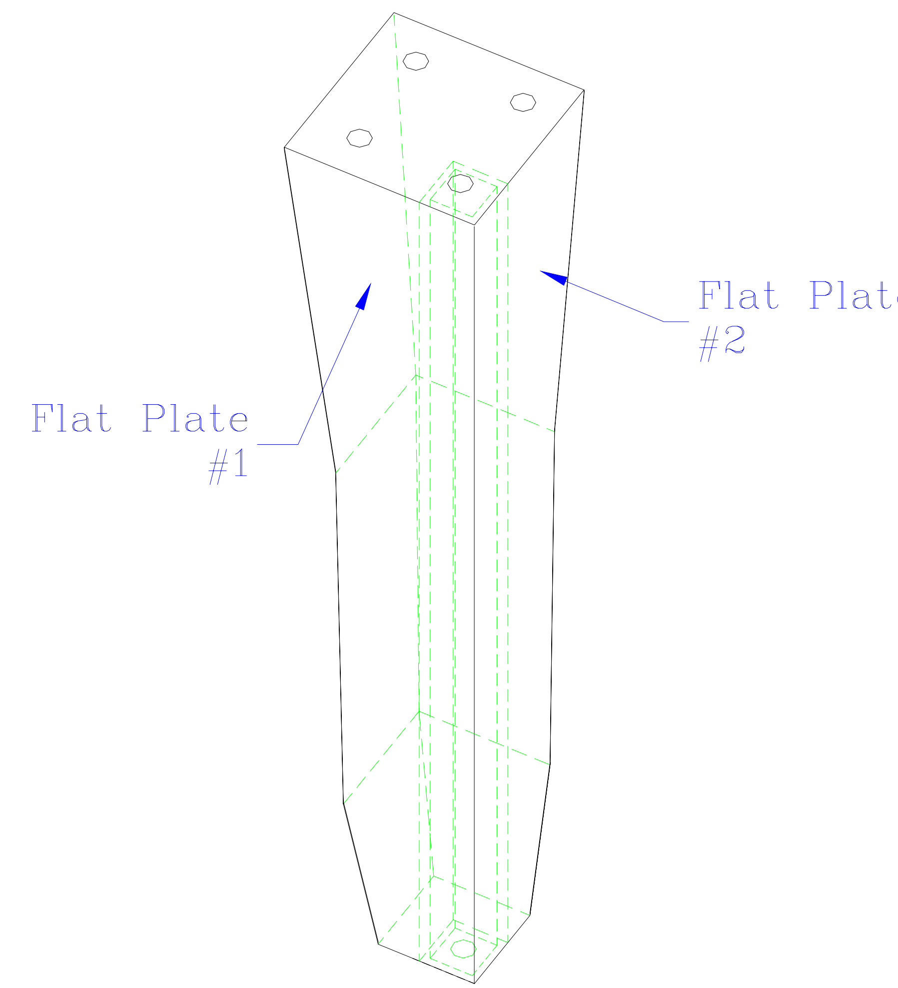
1. All dimensions are in millimeters unless otherwise shown.
2. Tan 8° = (76)/(537)
3. Phantom lines show section to be removed.




| | | |
|---|---|---|
| 100-150-W1 | 1 | Recycled carpet fiber wedge |
| Part ID No. | Quantity | Description |
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 5 | | Title: Common Wedge |
| Scale: None | File: common.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 5 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates)<br>~~7-17-98~~ 5-10-00 |



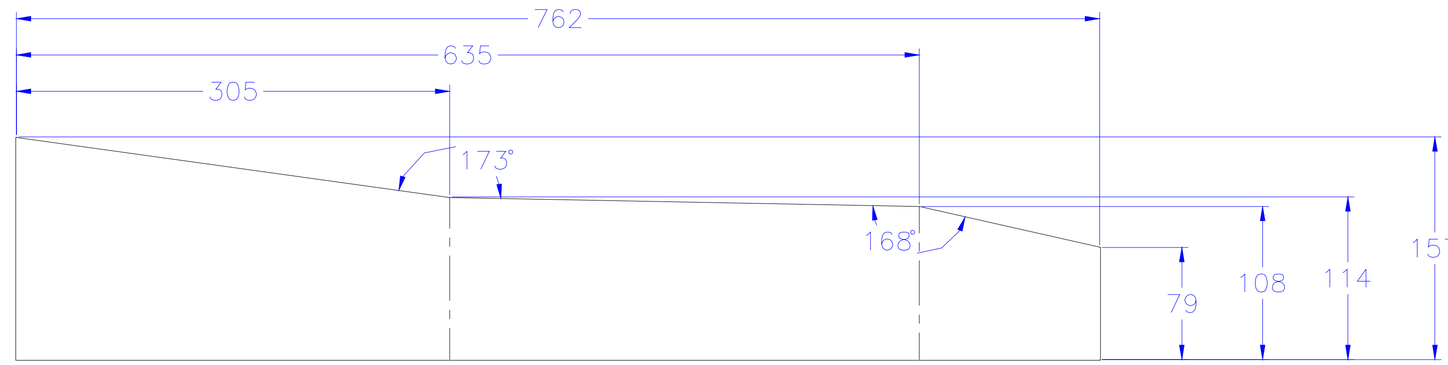

Front View



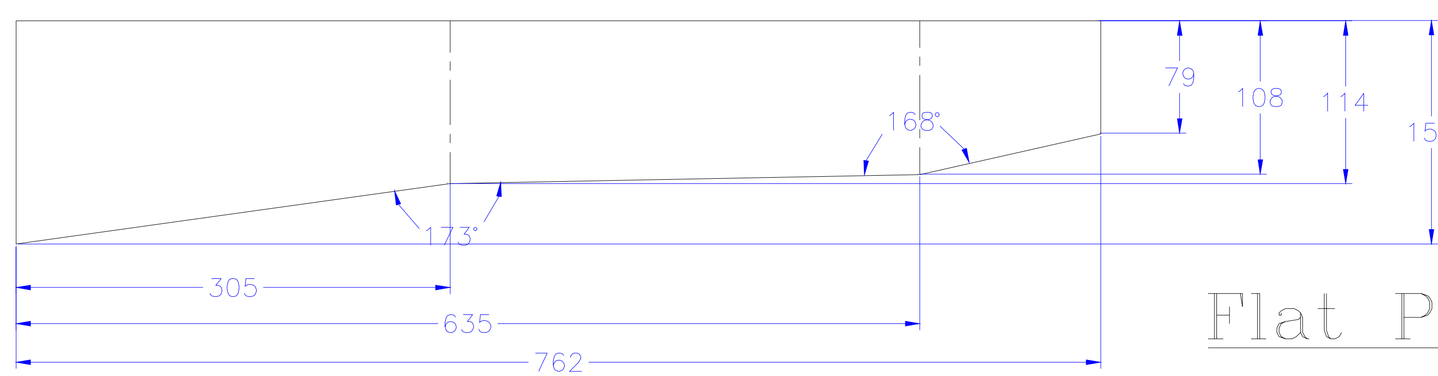

Rear View

Note:
All steel parts are 5mm thick
(11 gage).

| | | |
|---|---|---|
| 100-762SF<br>Part ID No. | 1<br>Quantity | Steel form for a 100x100x762 mm footing<br>Description |
| Unless otherwise specified tolerances are:<br>3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.:<br>Quick Change Sign Post 6 | | Title:<br>100x100 mm Steel Form |
| Scale:<br>None | File:<br>assy4x4.dwg | Drawn by: Natane Clarke — Checked by: M. White |
| Size:<br>A | Sheet 6 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates)<br>7-16-98, 5-10-00 |




Flat Plate #1

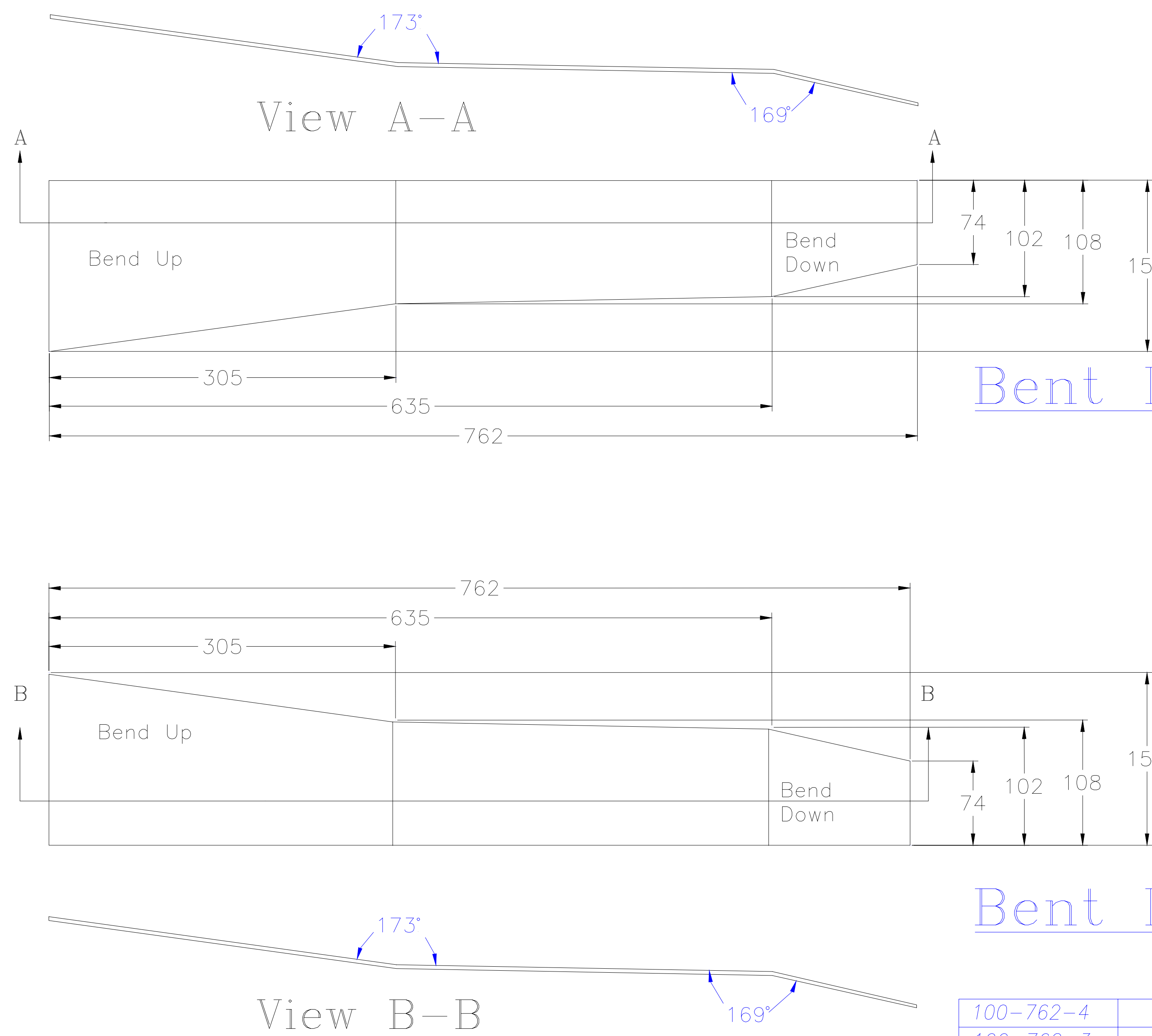



Flat Plate #2

Note:
1. All dimensions are in millimeters unless otherwise shown.

| Part ID No. | Quantity | Description |
|---|---|---|
| 100-762SF-1 | 2 | Steel plate 5mm thick or 11 gage. |
| 100-762SF-2 | 1 | Steel plate 5mm thick or 11 gage. |

| | | |
|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 7 | | Title: Bending Plan 100x100mm |
| Scale: None | File: stform4x4.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 7 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-17-98, 5-10-00 |




# Bent Plate #3

Note:

1. All dimensions are in millimeters unless otherwise shown.

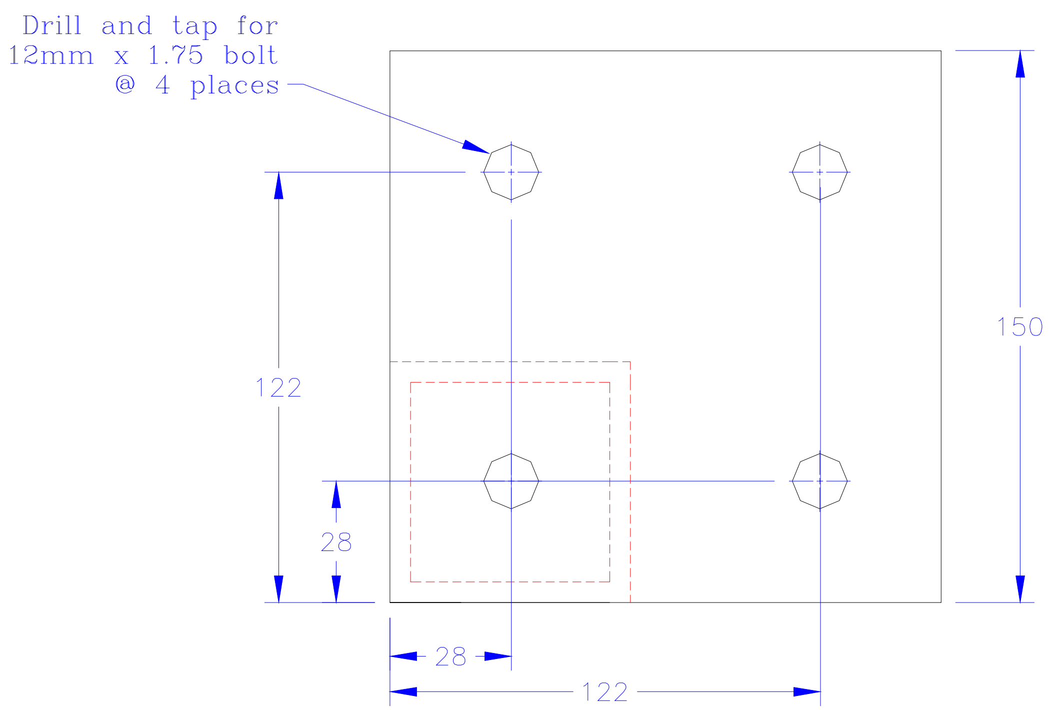
# Bent Plate #4

| Part ID No. | Quantity | Description |
|---|---|---|
| *100–762–4* | 1 | *Steel plate – 5mm thick or 11 gage.* |
| *100–762–3* | 1 | *Steel plate – 5mm thick or 11 gage.* |

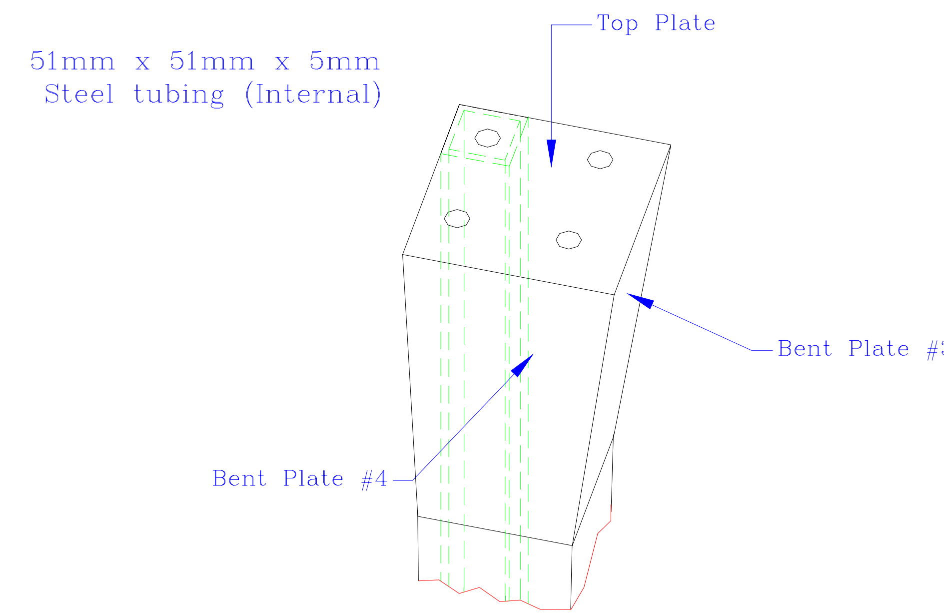
| | |
|---|---|
| Unless otherwise specified tolerances are: 3mm | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 8 | Title: 100x100mm Bent Pieces |

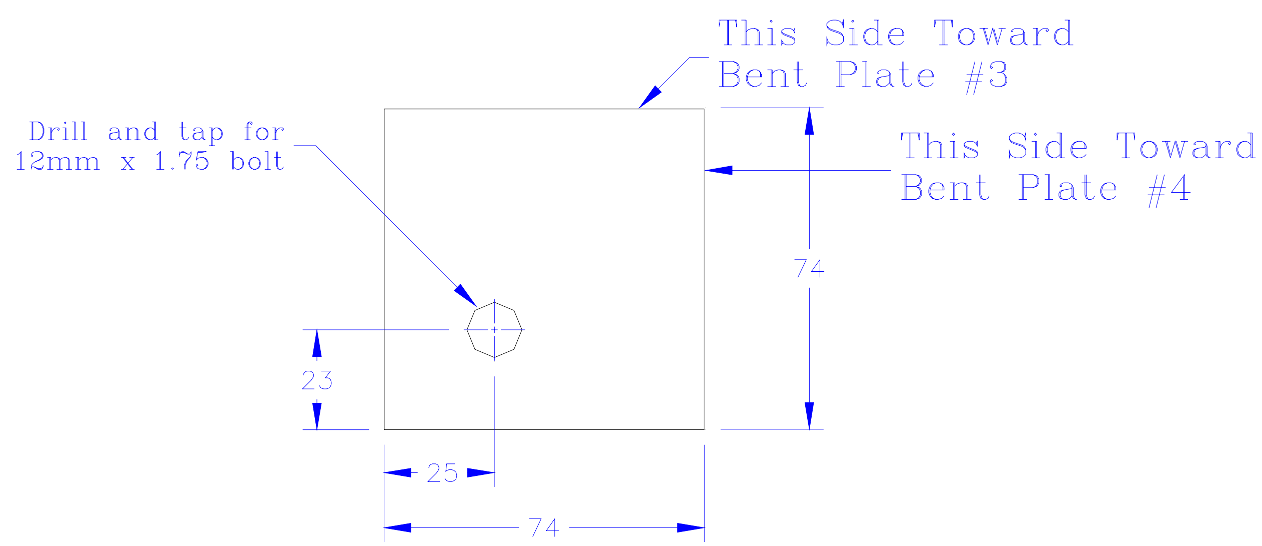
| Scale: | File: | Drawn by: | Checked by: |
|---|---|---|---|
| None | bform4x4.dwg | Natane Clarke | M. White |

| Size: | Sheet | Of | Revision Dates (Disregard Prints Bearing Earlier Revision Dates) |
|---|---|---|---|
| A | 8 | 13 | ~~7–16–98~~ 5–10–00 |

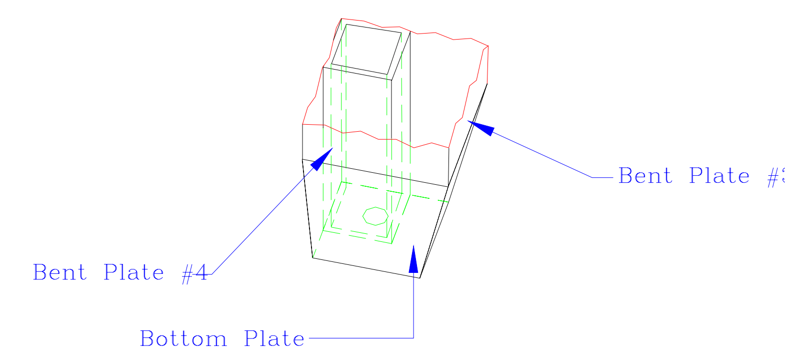



Top Plate, Top View



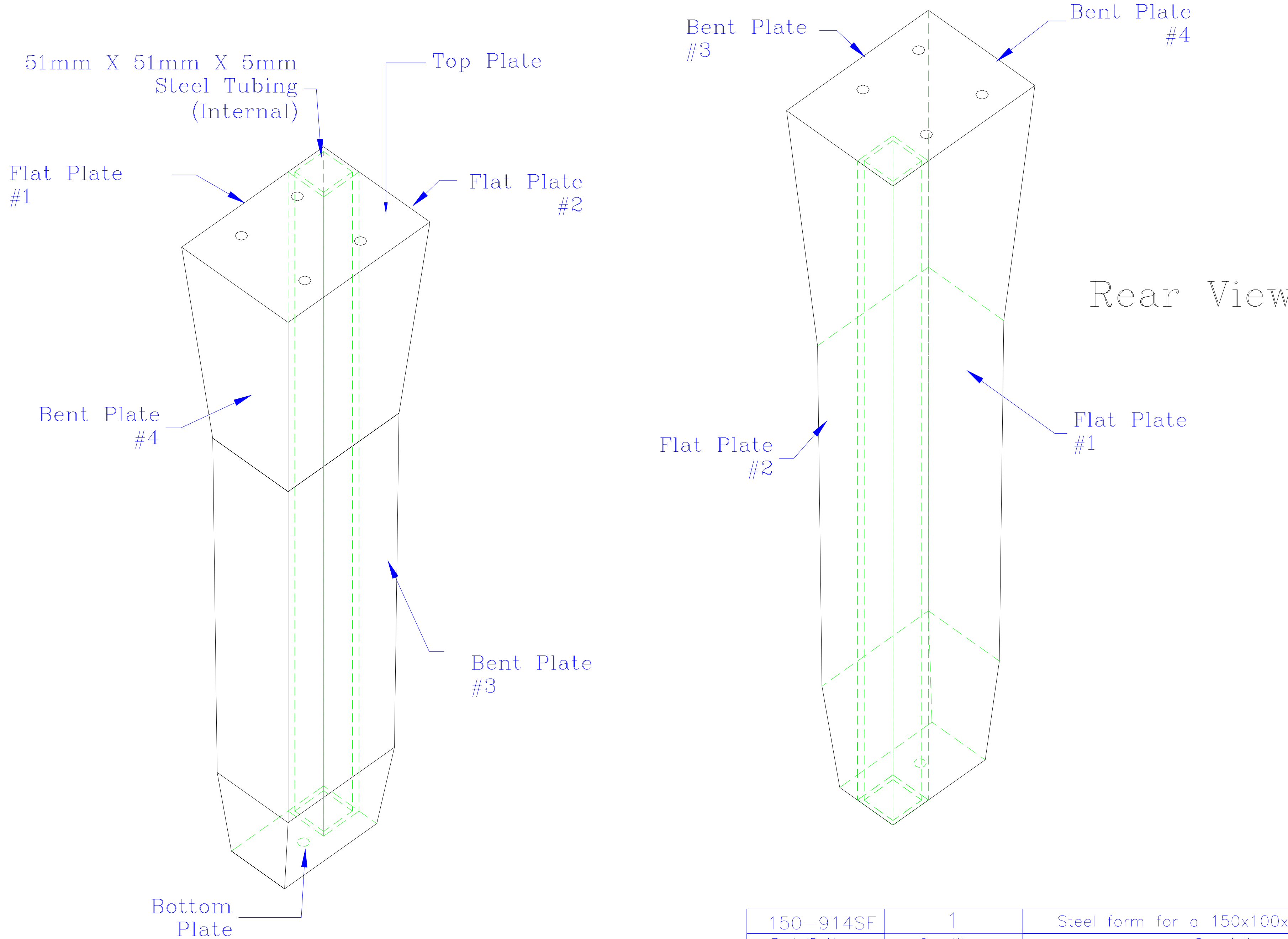




Bottom Plate




| Part ID No. | Quantity | Description |
|---|---|---|
| 100-914SF-T | 1 | Steel plate – 5mm thick or 11 gage. |
| 100-914SF-B | 1 | Steel plate – 5mm thick or 11 gage. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research | | | | |
| Drawing No.: Quick Change Sign Post 9 | | Title: 100x100 Top and Bottom Plates | | | | |
| Scale: None | File: tplt4x4.dwg | Drawn by: Natane Clarke | | Checked by: M. White | | |
| Size: A | Sheet 9 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates) | | | | |
| | | 7-17-98 | 5-10-00 | | | |




Front View

Note:
All steel plates are 5mm thick
(11 gage).

| Part ID No. | Quantity | Description |
|---|---|---|
| 150-914SF | 1 | Steel form for a 150x100x914mm footing |

Unless otherwise specified tolerances are: 3mm

STATE OF CALIFORNIA
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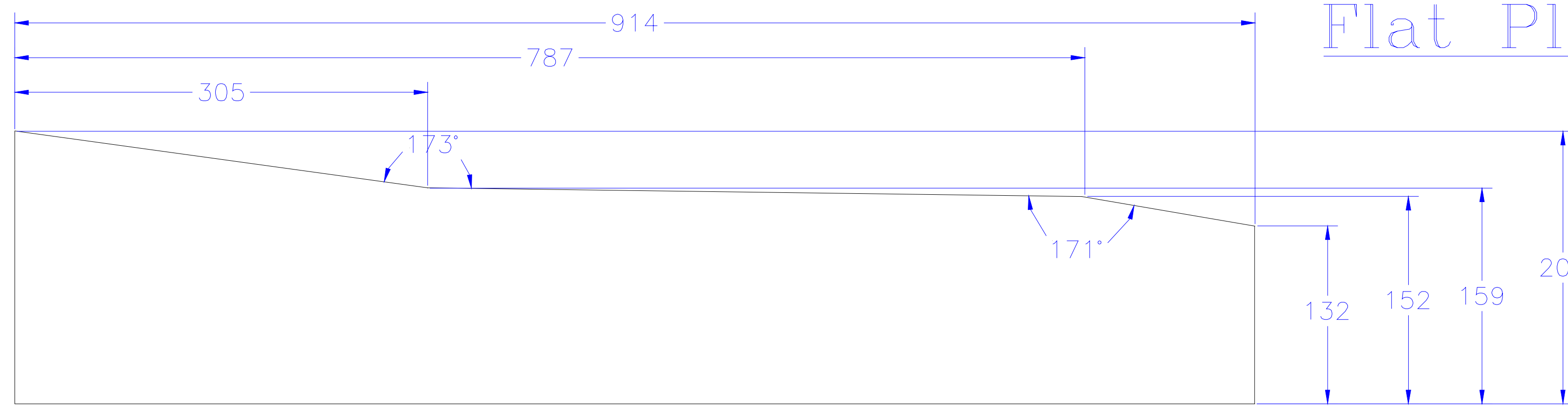
Office of Research

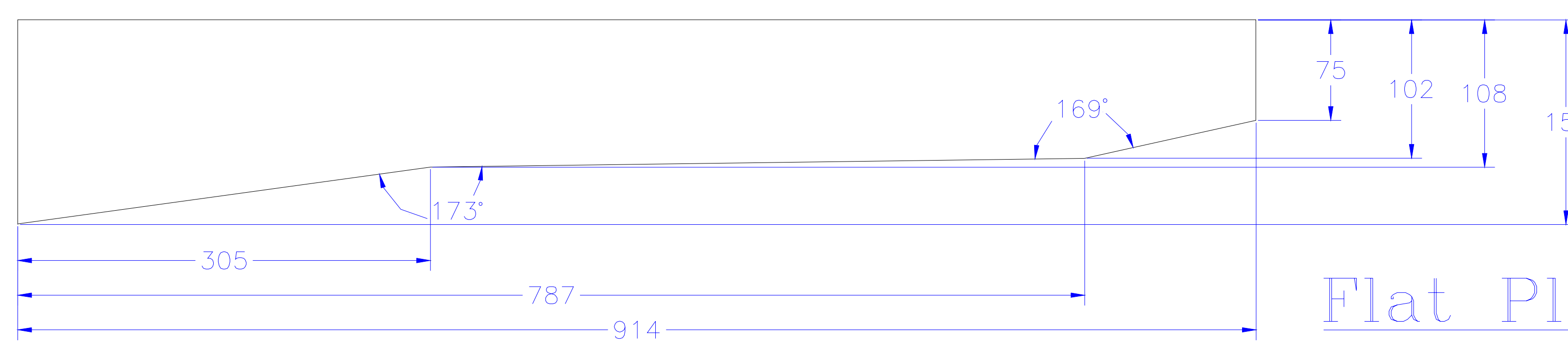
| | |
|---|---|
| Drawing No.: Quick Change Sign Post 10 | Title: 100x150mm Steel Form |
| Scale: None | File: assy4x6.dwg |
| Drawn by: Natane Clarke | Checked by: M. White |
| Size: A | Sheet 10 Of 13 |

Revision Dates (Disregard Prints Bearing Earlier Revision Dates): ~~7-16-98~~ 5-10-00

# Flat Plate #1




# Flat Plate #2

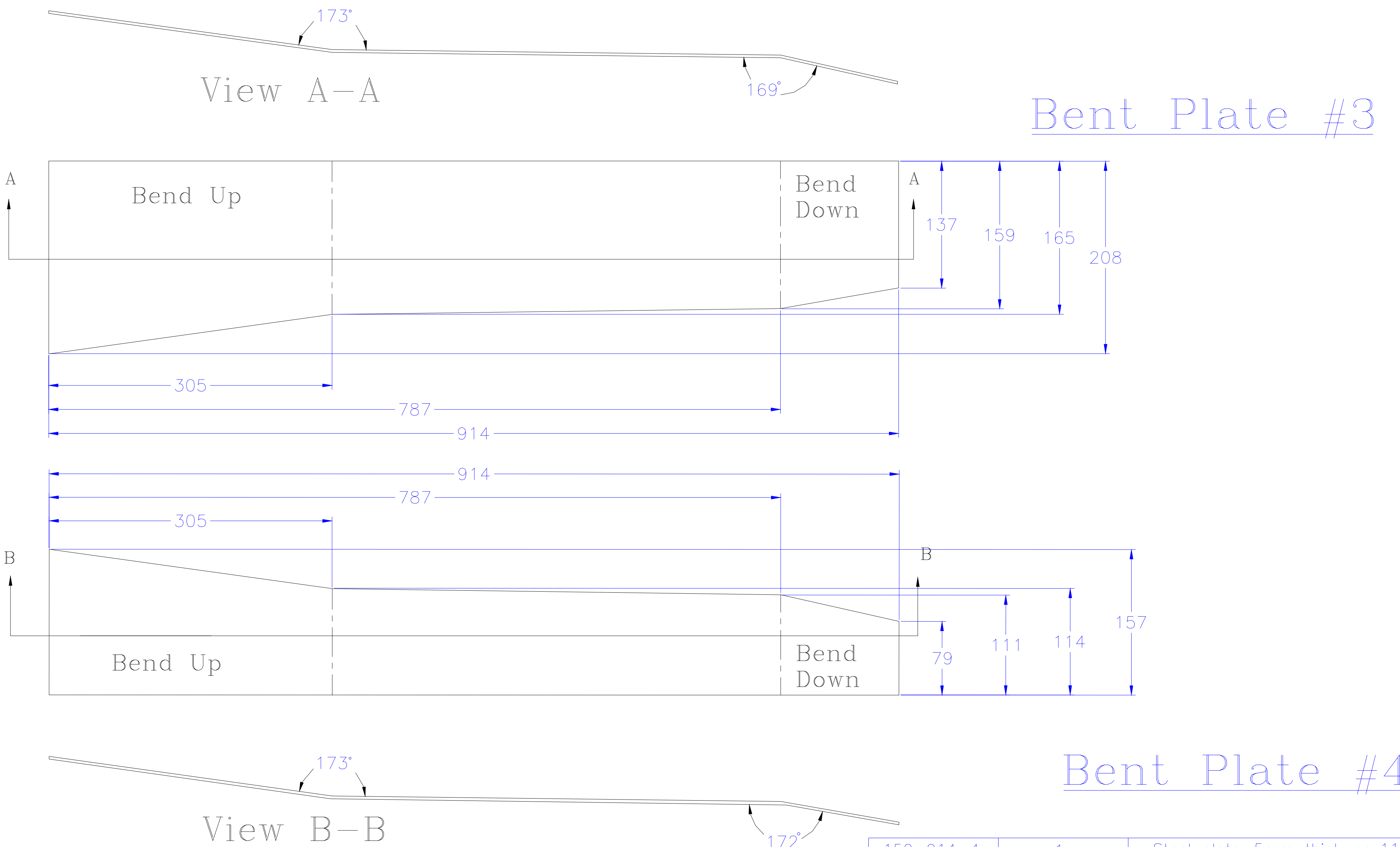



Note:

1. All dimensions are in millimeters unless otherwise shown.

| Part ID No. | Quantity | Description |
|---|---|---|
| 150–914–2 | 1 | Steel plate–5mm thick or 11 gage. |
| 150–914–1 | 1 | Steel plate–5mm thick or 11 gage. |

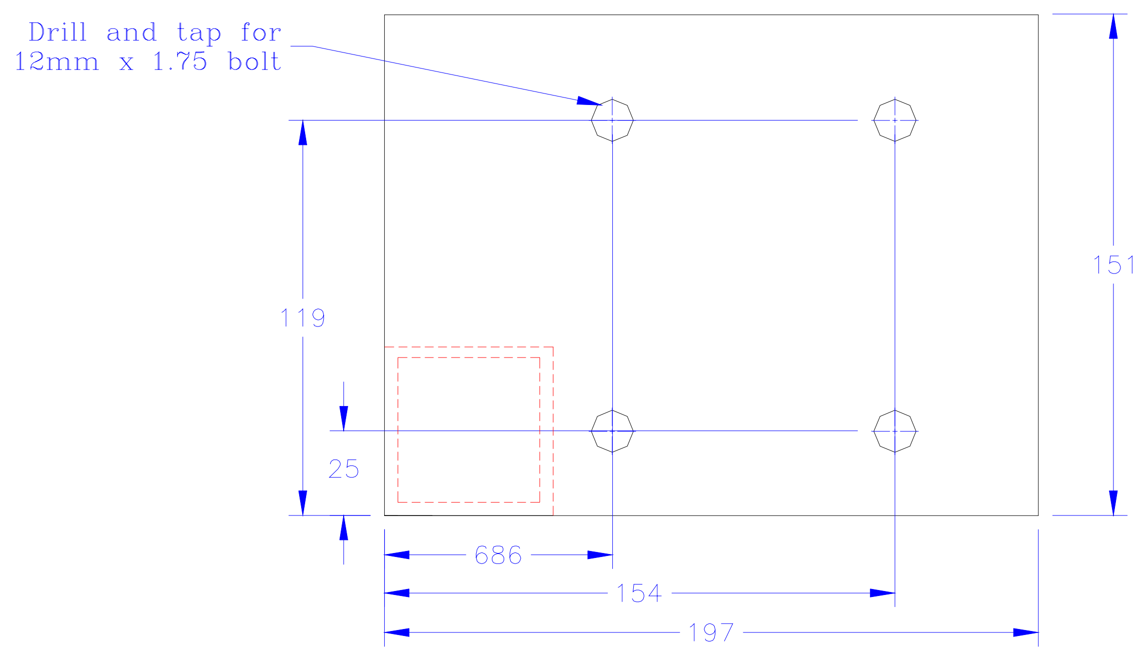
| | | | | | | |
|---|---|---|---|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research | | | | |
| Drawing No.: Quick Change Sign Post 11 | | Title: 100x150mm Straight Pieces | | | | |
| Scale: None | File: stform 4X6.dwg | Drawn by: Natane Clarke | | Checked by: M. White | | |
| Size: A | Sheet 11 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates) | | | | |
| | | ~~7–16–98~~ | 5–10–00 | | | |



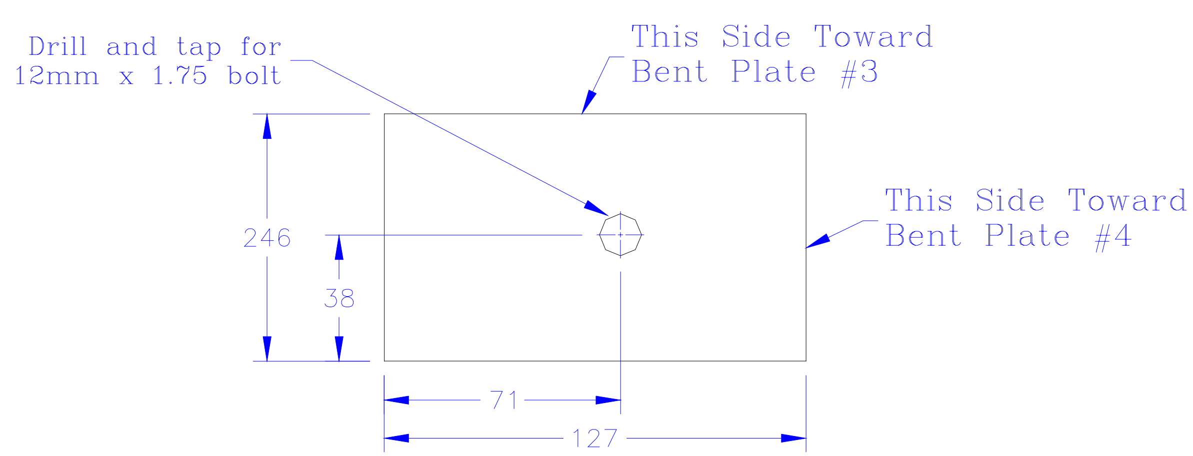

Note:
1. All dimensions are in millimeters unless otherwise shown.

| Part ID No. | Quantity | Description |
|---|---|---|
| 150-914-4 | 1 | Steel plate-5mm thick or 11 gage. |
| 150-914-3 | 1 | Steel plate-5mm thick or 11 gage. |

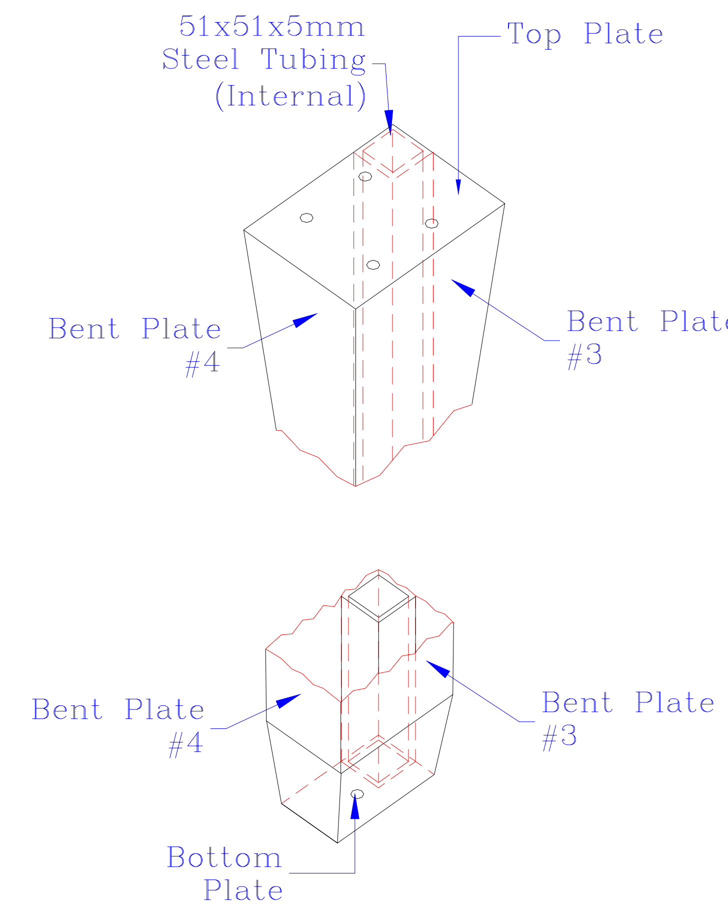
| | | |
|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 12 | | Title: 100x150mm Bent Pieces |
| Scale: None | File: bform 4X6.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 12 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-16-98, 5-10-00 |




Top View



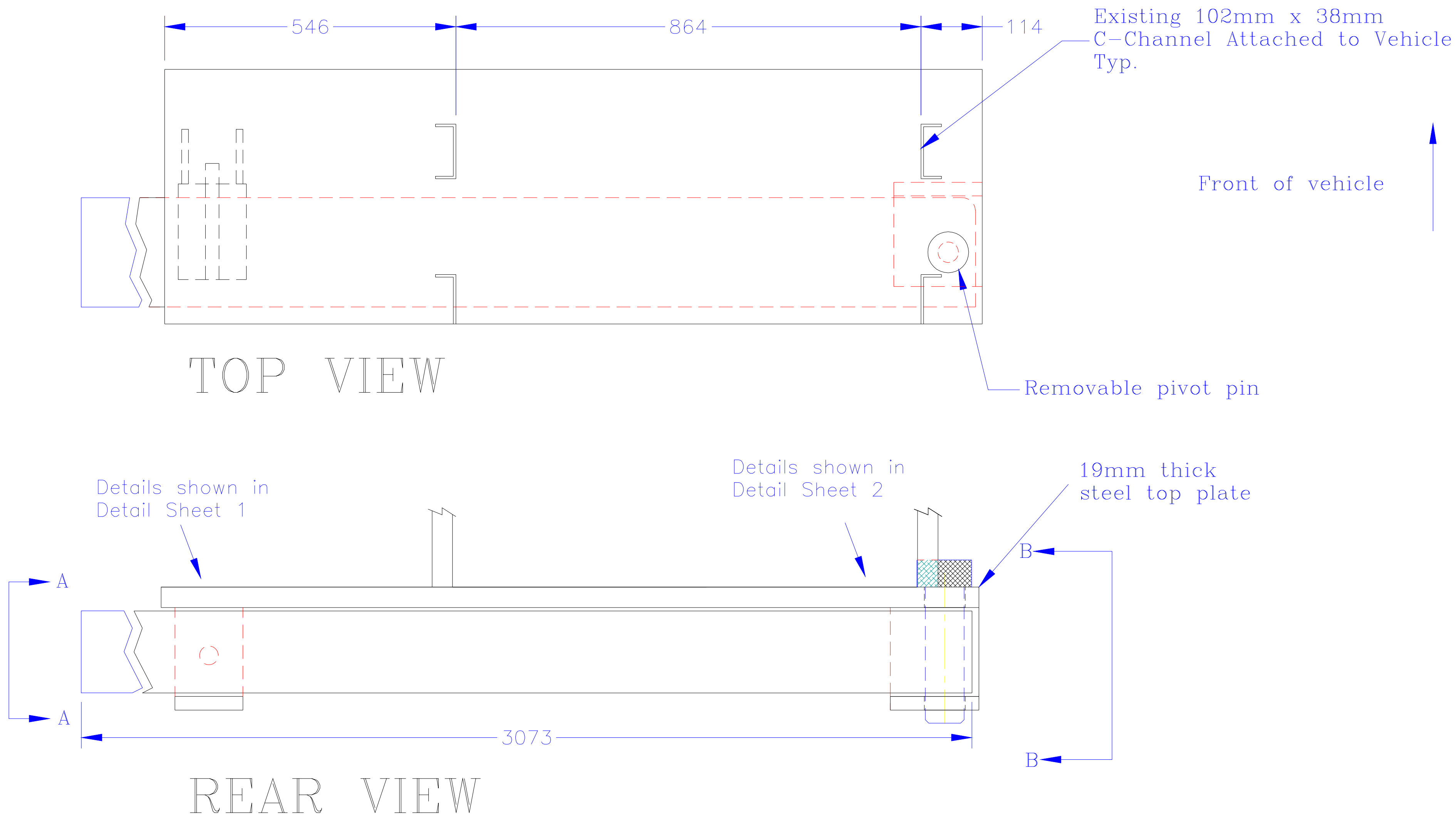

Bottom Plate




Note:

1. All dimensions are in millimeters unless otherwise shown.

| | | |
|---|---|---|
| 150-914SF-T | 1 | Steel plate-5mm thick or 11 gage. |
| 150-914SF-T | 1 | Steel plate-5mm thick or 11 gage. |
| Part ID No. | Quantity | Description |
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Quick Change Sign Post 13 | | Title: 100x150 mm Top and Bottom Plates |
| Scale: None | File: tplt4x6.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 13 Of 13 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-17-98, 5-10-00 |



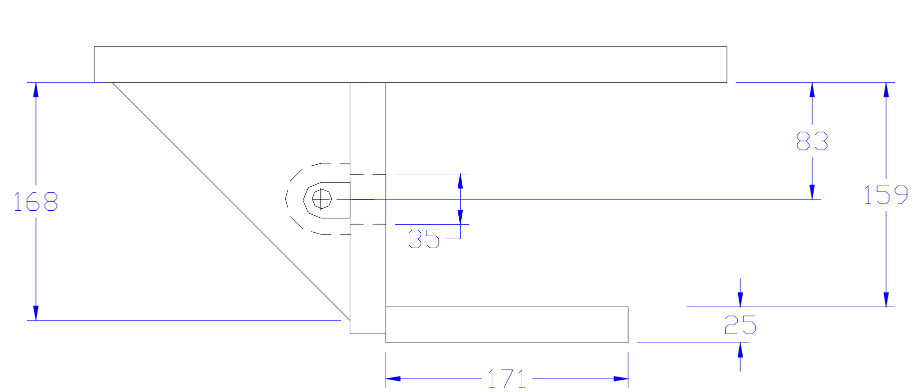

Notes:

A. This setup supports an 203mm x 152mm x 3073mm long steel beam.

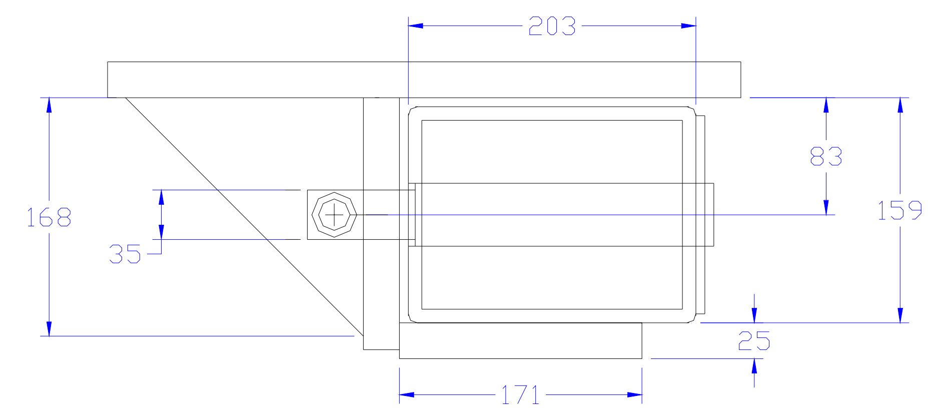
B. All measurements are in millimeters.

C. Guide Pin and Shear Pin shown in detail on Detail Sheet 3.

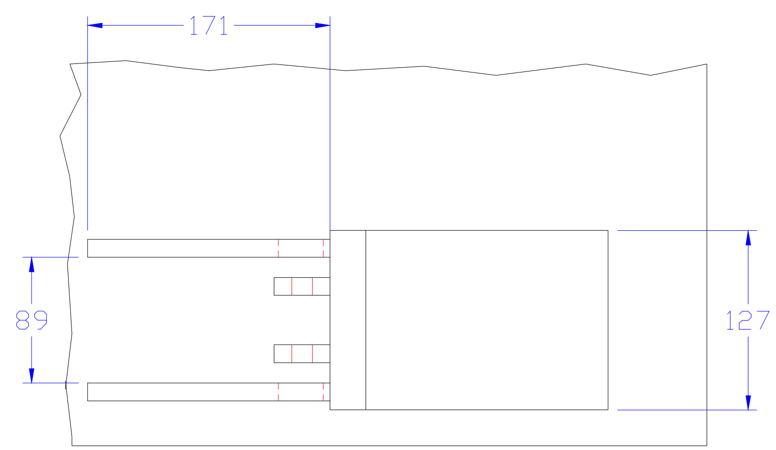
| Part ID No. | Quantity | Description |
|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Beam 1 | | Title: Knock Down Beam |
| Scale: None | File: Bsupp.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 1 Of 4 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-15-98, 3-13-00 |




VIEW A–A without beam

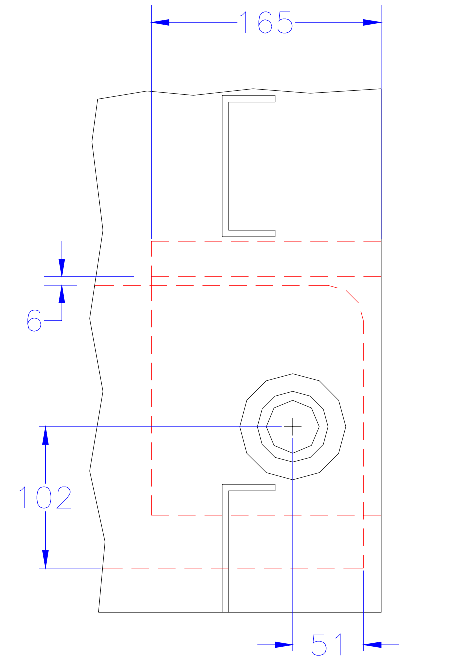



VIEW A–A with beam

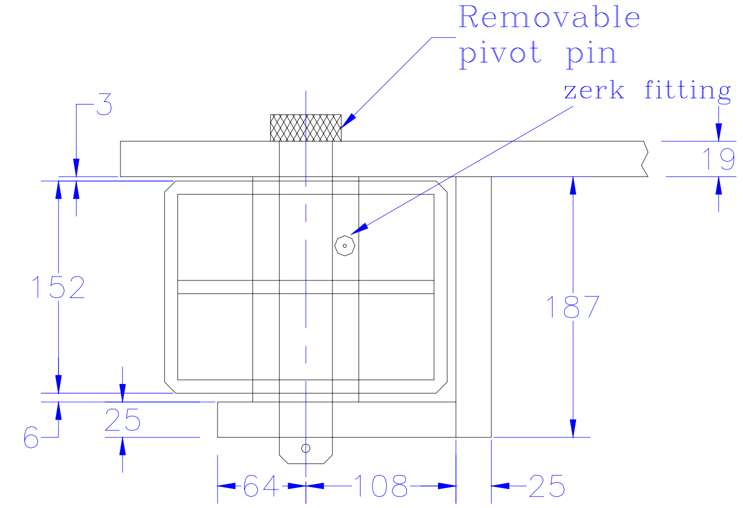



Note
Plate Support is 10mm thick.
Pin Support is 19mm thick.

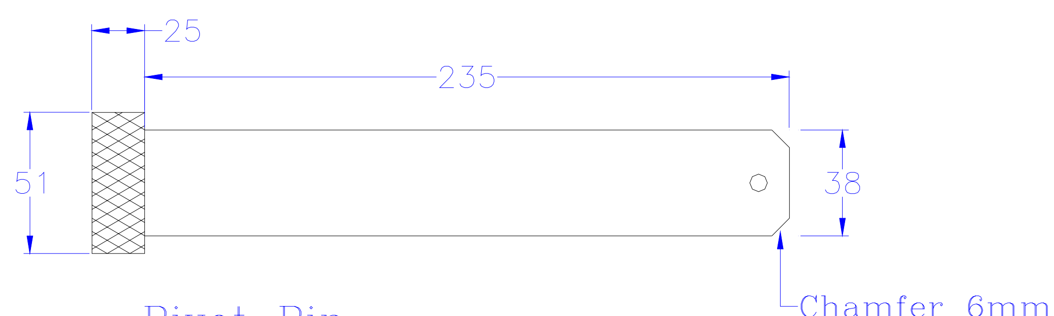
| Part ID No. | Quantity | Description |
|---|---|---|
| Unless otherwise specified tolerances are: 3mm | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Beam 2 | | Title: KDB Detail Sheet 1 |
| Scale: None | File: detSHEARJNT.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 2 Of 4 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): ~~7-15-98~~ 3-13-00 |




TOP VIEW

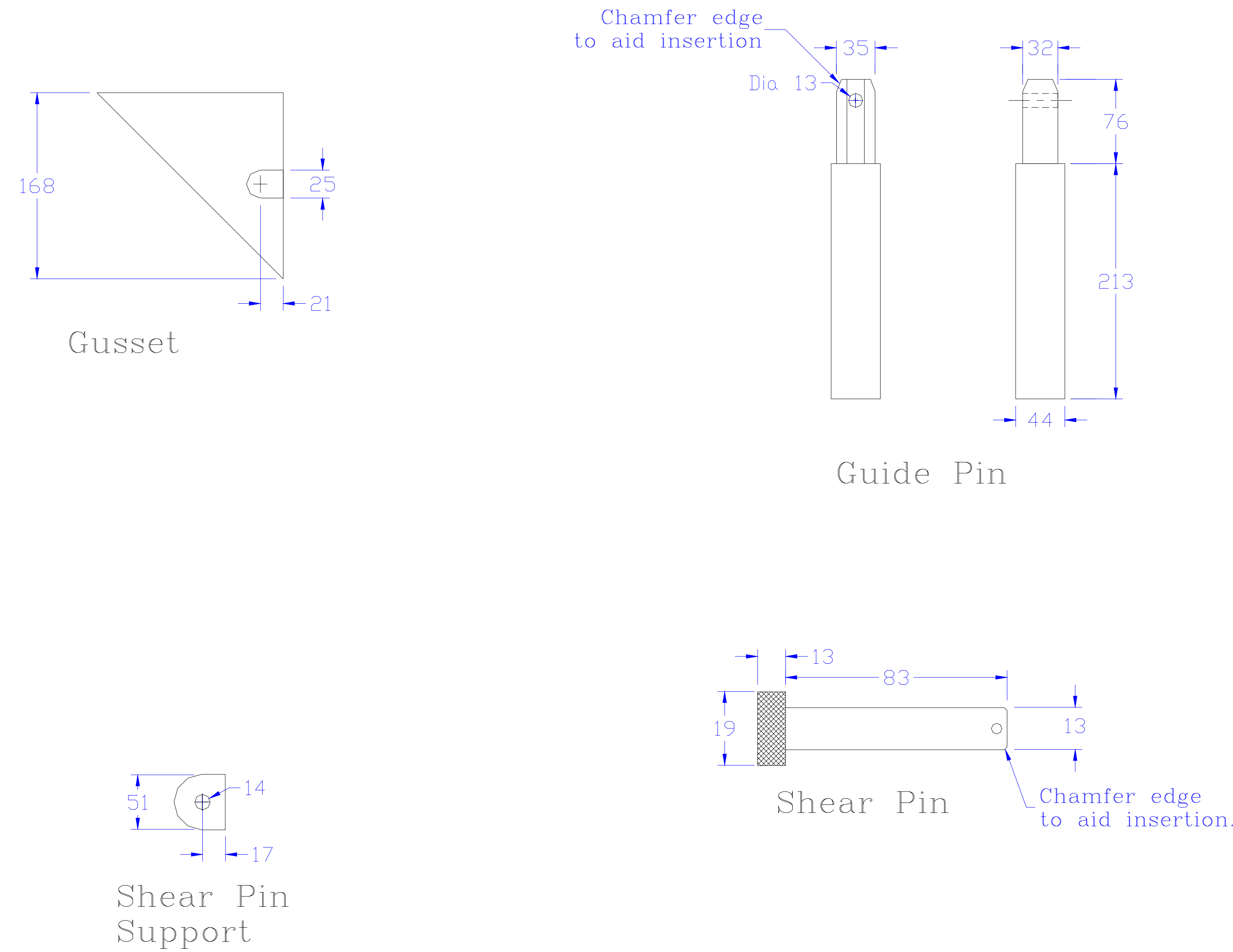



VIEW B-B




Pivot Pin

| Part ID No. | Quantity | Description |
|---|---|---|
| | 1 | |
| Unless otherwise specified tolerances are: | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Beam 3 | | Title: KDB Detail Sheet 2 |
| Scale: None | File: pinjoint.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 3 Of 4 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-17-98, 3-13-00 |




| Part ID No. | Quantity | Description |
|---|---|---|
| | 1 | |
| Unless otherwise specified tolerances are: | | STATE OF CALIFORNIA<br>DEPARTMENT OF TRANSPORTATION<br>Office of Research |
| Drawing No.: Beam 4 | | Title: KDB Detail Sheet 3 |
| Scale: None | File: shearjnt.dwg | Drawn by: Natane Clarke / Checked by: M. White |
| Size: A | Sheet 4 Of 4 | Revision Dates (Disregard Prints Bearing Earlier Revision Dates): 7-16-98, 3-13-00 |

# Appendix B

## Blank copy and Summary of “Hit” Sheets

Page B2 contains a blank copy of the sheet that was given to District personnel to fill out and FAX back after one of the signposts installed in a QCSP footing was hit.

Page B3 is the summary of “hit” sheet that were faxed in from District crews.

# QCSP FAX SHEET

| | | | | |
|---|---|---|---|---|
| To: | Mike White | From: | ____________________ | District_________ |
| Phone: | (916) 227-7115 | Phone: | ______________________________________ | |
| FAX: | (916) 227-7117 | FAX: | ______________________________________ | |

(Calnet prefix is 498)

Please call me if you would like to provide more information or comments or if you have any questions about this project.

Date of "hit"_____________ Location __________________________________________

4x4 _____ 4x6 _____ Breakaway holes? _________ Sign type __________________

Time arrived on scene _________________ Time departed scene ______________________

Weather and/or soil conditions ____________________________________________________

Wedges reused? _____________ Footing condition _________________________________

**Comments and/or suggestions:**

# QUICK CHANGE SIGN POST FAX SHEET SUMMARY

| | Date of Hit | Location | 4X4 or 4X6 | Break Away Holes | Sign Type | Time Arrived on Scene | Time Departed Scene |
|---|---|---|---|---|---|---|---|
| 1 | N/A | N.B 51, Marconi Exit | 4X6 | No | Exit | 9:25 AM | 9:30 AM |
| 2 | N/A | N.B 51, Marconi Off | 4X6 | No | Exit | 8:42 AM | 8:45 AM |
| 3 | 2/20 & 2/22/98 | Hum 254, PM 43.5 | 4X4 | No | Stop | 9:00 AM | 9:10 AM |
| 4 | 2/27/1998 | N.B 51, Marconi Off Ramp | 4X6 | No | G84 Exit | 12:54 PM | 12:58 PM |
| 5 | 4/18/1998 | E.B. 24 Pleasant Hill RD. | 4X4 | No | W 81 | 9:45 AM | 10:00 AM |
| 6 | 4/23/1998 | E.B. 24 Pleasant Hill RD. | 4X6 | No | W4 | 9:45 AM | 10:15 AM |
| 7 | 5/6/1998 | E.B. 24 Pleasant Hill RD. | Both | No | W4 & W81 | 1:00 PM | 1:45 PM |
| 8 | 6/9/1998 | W.B. SCL 152 P.M. 34.2 | 4X6 | Yes | 48"X48"X36" | 12:20 PM | 1:00 PM |
| 9 | 7/1/1998 | Hum 255, A.M. 2.0 | 4X6 | Yes | #12,994 | 2:00 PM | 2:45 PM |
| 10 | 8/19/1998 | Marconi Off Exit | 4X6 | No | Exit | 3:25 PM | 3:30 PM |
| 11 | 12/24/1998 | N.B 51, Marconi | 4X6 | No | G84 Exit | 8:15 AM | 8:20 AM |
| 12 | 1/25/1999 | SCL 152 W/B P.M. 34.2 | 4X6 | Yes | W29-1 & W29-C | 2:00 PM | 2:45 PM |
| 13 | 8/23/2001 | N.B.5 PM 9.6 | 4X6 | Yes | W59 | 10:00 AM | 10:40 AM |
| 14 | 11/4/2001 | N.B.5 to W.B.78 | 4X6 | Yes | G84 | 9:00 AM | 9:45 AM |
| 15 | 12/20/2001 | N.5 to W.78 | 4X6 | Yes | G84 | 8:30 AM | 9:20 AM |
| 16 | 1/28/2002 | N.B.5 P.M. 32.7 | 4X6 | Yes | G84 Exit | 1:10 PM | 1:21 PM |

| | Weather/Soil Conditions | Footing Conditions | Wedges Reused | Comments and/or Suggestions |
|---|---|---|---|---|
| 1 | Good | Excellent | Yes | No comments |
| 2 | Good | Good | Yes | No comments |
| 3 | Rain-Pavement | N/A | Yes | Very easy and simple to replace, good improvement |
| 4 | Cloudy | OK | Yes | No comments |
| 5 | Clear-Dry | Moved slightly | Yes | Footing may have moved slightly from hit--off just a little |
| 6 | Clear-Damp | Good, repositioned | Yes | No comments |
| 7 | Cloudy/Damp to Muddy | Both Footings Moved | Yes | Both footings are off center, suggest replanting them |
| 8 | Dry-Windy/Damp | Good | Yes | Low speed hit |
| 9 | Fair/Sandy Soil | Out of Level | No | Sign was hit from wrong direction-can benefit sign crews |
| 10 | Good/Dry | Sound & Excellent | Yes | No comments |
| 11 | Clear | Good | Yes | No comments |
| 12 | Clear/Moist Soil | Good | Yes | No problems replacing sign |
| 13 | Fair | Good | Yes | No comments |
| 14 | Overcast/Dry soil | Poor (no compaction) | Yes | Poor compaction around base |
| 15 | Clear & Dry | Loose | No | Replaced 3 times |
| 16 | Windy, rainy, soil wet | Good | Yes | Very good installation |

# Appendix C

## Instruction Sheets for Initial Installation and Replacement

Page C2-C3 contains an instruction sheet that was distributed with the footing to assist the crews with the initial installation procedure.

Page C4 contains an instruction sheet on how to remove a broken signpost after it has been hit and how to correctly install the new signpost and wedges.

# FOOTING INSTALLATION INSTRUCTIONS

1. Select and mark site for footing installation
2. Position auger truck
3. Ensure the auger is plumb before starting and several times during the augering operation
4. Use an 18” minimum auger bit (24" is preferred) to make a hole 54” deep
5. Using crushed gravel, backfill the hole to a depth of 48”, It can be 47” to allow for settling of the footing, but it cannot be more than 48” or the footing will be slightly below grade. The gravel is to aid drainage.
6. Roll or store the auger bit
7. Attach the 3/4” eyebolts to the footing. Thread and secure the lifting chain. Hook the chain on the boom cable.
8. Carefully lift the footing to vertical and position it over the hole.
9. Lower the footing into the hole taking care not to knock an excessive amount of native soil into the hole. (Clay soils will block the drain hole allowing water to collect in the footing cavity. This will cause the wood to swell and may make removal difficult).
10. Before the footing is lowered completely, make sure the arrow embossed on the top of the footing is pointing in the direction of traffic flow.
11. Lower the footing, disconnect the chain, and move the boom away.
12. Remove the eyebolts from the footing. Place grease in the threaded insert holes and reinstall the plastic plugs. Be sure this is done prior to beginning to fill the hole or soil will fill these threaded holes.
13. Place a good quality, full size post into the cavity and lightly place the wedges in their corresponding locations. The large wedge with the “dog-leg” cut goes on the upstream side. Be sure the side of the wedge with the 90 degree side goes against the wood post. (The post used could be the one with the sign panel already attached).
14. Check that the footing is close to plumb and that it is properly oriented with the travel way.
15. Using a level, have one person hold the post/footing plumb, (a slight tilt toward oncoming traffic may be desirable), while another uses native soil to backfill around the footing and tamp it down. This should be done in approximately 8” lifts.
16. Once satisfied that the footing is properly and securely installed, lightly hammer the wedges down to seat them. DO NOT USE EXCESSIVE FORCE OR A LARGE NUMBER OF HAMMER BLOWS. Excessive force is unnecessary and will only make removal difficult.
17. Scatter the unused native soil along the shoulder or elsewhere will it will not pose a risk to motorists

# REMOVAL AND REPLACEMENT INSTRUCTIONS

1. Clear broken post debris from around the footing.
2. Place the pick end of the pickax fully into the hole in one of the wedges.
3. Tilt the pickax handle toward the center of the footing to allow placement of a 2 LB sledgehammer head, (or other spacer material), between the head of the pickax and the top surface of the footing. This is to provide leverage.
4. Grasp the end of the pickax handle and pull away from the center of the footing while placing downward pressure on the flat end of the pickax with either foot. You may have to fully stand on the flat end of the pickax.
5. The wedge should pull free, sometimes suddenly.
6. If the wedge does not come loose easily, use another hammer to strike the sides to help work it loose.
7. Again apply pressure with the pickax. If the wedge does not come loose, you may have to strike the sides with one hammer while applying pressure with the pickax.
8. If the wedges cannot be removed using a pickax, use a hex bar and a piece of the broken post, (for leverage), to remove the wedges using the same holes as above.
9. Once loose, remove the wedges and set aside.
10. Remove the broken stub from the cavity.
11. Make sure the cavity is fairly clear of foreign material.
12. Insert the new signpost into the cavity letting it fall all the way to the bottom.
13. Insert the large wedge with the “dog-leg” cut on the upstream side. Be sure the side of the wedge with the 90 degree side goes against the wood post, or that the side with the "dog-leg" cut is toward the other wedge
14. Insert the other wedge into the cavity on the traffic side of the post. Again, be sure the side of the wedge with the 90 degree side goes against the wood post.
15. Once satisfied that the post is properly placed, lightly hammer the wedges down or merely step on them with full body weight to seat them. DO NOT USE EXCESSIVE FORCE OR A LARGE NUMBER OF HAMMER BLOWS. This is unnecessary and will only make removal difficult
16. Collect remaining post debris and depart the scene

# Appendix D

## List of Dynamic Tests

Conducted on 10/30/96

TEST #1 at 9:10 AM, speed: 21.8 mph.
Knocked down a 4"x4" wood post with a R-1 STOP sign in a 24" diameter footing which had been soaking for 7 days. Left "as is" after the hit. Record the hit on high speed, film and video.

TEST #2 at 9:29 AM, speed: 22.1 mph.
Knock down a 4"x4" wood post with a R-1 STOP sign in a 24" diameter footing after soaking for 7 days. Leave "as is" after the hit. Record the hit on high speed, film and video.

TEST #3 at 9:55 AM, speed: 20.8 mph
Knock down a 4"x6" wood post with a G-84 EXIT sign in a 24" diameter footing after soaking for 7 days. Leave "as is" after the hit. Record the hit on high speed, film and video.

TEST #4 at 10:05 AM, speed: 22.0 mph.
Knock down a 4"x6" wood post with a G-84 EXIT sign in a 24" diameter footing after soaking for 7 days. Leave "as is" after the hit. Record the hit on high speed, film and video.

TEST #5 at 10:15 AM, speed: 22.6 mph.
Install a 4"x4" wood post in an 18" diameter footing with a R-1 STOP sign. Knock down and record the hit on high speed, film and video. Demonstrate how to remove the broken stub and install a new post with sign attached. Discussion.

TEST #6 at 10:45 AM, speed: 23.0 mph.
Knock down a 4"x4" wood post in an 18" diameter footing with a R-1 STOP sign. Record the hit on high speed, film and video. Have a crew remove the broken stub and install a new post with sign attached. Record the crew on video and time them. Check the footing closely for signs of movement. Discussion. Remove that post.

TEST #7 at 11:10 AM, speed: 21.0 mph.
Have a crew install a 4"x6" wood post with no breakaway holes in an 18" diameter footing without a sign panel. Knock down and record the hit on high speed, film and video. Have a crew remove the broken stub and install a new post with sign attached. Record the crew on video and time them. Discussion.

TEST #8 at 11:29 AM, speed: 22.2 mph.
Have a crew install a 4"x6" wood post with no breakaway holes in an 18" diameter footing without a sign panel. Knock down and record the hit on high speed, film and video. Have a crew remove the broken stub and install a new post with sign attached. Record the crew on video and time them. Discussion. Remove that post.

TEST #9 at 11:45 AM, speed: 22.2 mph.

Have a crew install a 4"x6" wood post in an 18" diameter footing with a G-84 EXIT sign. Knock down and record the hit on high speed, film and video. Have a crew remove the broken stub and install a new post with sign. Record the crew on video and time them. Discussion. Remove that post.

TEST #10 at 10:55 AM, speed: 18.9 mph.
Have a crew install a 4"x4" wood post in an 18" diameter footing with a R-1 STOP sign. Knock down and record the hit on high speed, film and video. Have a crew remove the broken stub and install a new post with sign attached. Record the crew on video and time them. Check the footing closely for signs of movement. Discussion. Remove that post.

TEST #11 at 1:30 PM, speed: 21.8 mph.
Have a crew auger an 18" diameter hole 48" deep and install the footing for the Lancaster Composite 40 Post. Backfill will native soil and tamp. Install the L40 post, without a sign panel, in the schedule 80-pipe using a set, screw. Knock down and record the hit on high speed, film and video. Have a crew remove the fractured post and install a new post with a R-1 STOP sign attached. Check the footing closely for signs of movement. Discussion.

TEST #12 at 2:00 PM, speed: 34.8 mph.
Knock down a Lancaster Composite 40 Post in an 18" diameter footing without a sign panel. Record the hit on high speed, film and video. Have a crew remove the fractured post. This is the second hit on the same footing so check the footing closely for signs of movement. Discussion.

# Appendix E

## Cost comparison of using this quick-change signpost system over the currently used system of placing signposts in augered holes in soil

**Cost Per Unit**

| | | |
|---|---|---|
| Concrete | 0.26 CY @ $63/CY | $16.50 |
| Rebar hoops | 2 ea @ $1.50/ea | $3.00 |
| Wedges | 2 ea @ $10/ea | $20.00 |
| Inserts | 2 ea @ $1.06/ea | $2.12 |
| Cardboard tube | 1 ea @ $12.50/ea | $12.50 |
| Labor | 2 person hours @ $23/hr | $46.00 |
| Total (approx.) | | $100.00 |

These estimates are based on production quantities of 12 footings per casting. If the footings are produced in large volume, the cost per unit could drop to less than $50.

Note: The following cost is associated with the construction of the steel form used to create the cavity within the concrete footing.

| | | |
|---|---|---|
| Forms | 10 hrs @ $12.00/hr | $120.00 |

Because this $120 is a one-time cost and the form could be used to make hundreds of footings the resulting cost per footing was deemed negligible.

**Cost for Initial QCSP Installation**

The typical installation requires three persons and three vehicles, an auger truck, cone truck, and a shadow vehicle with a TMA. Upon arrival at the scene, the auger truck is parked. The lane closure is accomplished with two persons operating the cone truck and the third person operating the shadow vehicle. After the closure is completed, the shadow truck is placed to provide protection for the crew. All three crewmembers would then work on the installation of the footing.

An 18” minimum diameter auger is used to create a hole to a depth of 52”. The bottom 4” of the hole is filled with ¾” crushed gravel to provide drainage. The footing is then lowered into the hole while maintaining proper orientation with the roadway. The signpost is placed into the cavity of the footing. The wedges are positioned, and set lightly with a small sledgehammer. A level is then used to ensure the post is plumb, (or leaning very slightly into the traffic), while native soil is used to backfill the annular space around the footing. This back fill should be placed and tamped in approximately 8” lifts. The auger truck is again parked while the lane closure is removed.

Cost estimate:
1.08 hours x 3 persons = 3.25 person hours

3.25 person hours x $28 per person = $91

**Cost for Post Replacement in a QCSP Footing**

One person serves as lookout while the other removes the wedges, removes the broken stub, installs the new post, and hammers the wedges back in place.

Cost estimate:
0.17 hours x 2 persons = 0.34 person hour

0.34 person hour x $28 per hour = $9.52

**Cost for Wood Post in Soil Replacement**

High hit locations are typically within an urban area. In these areas, the daily traffic volume usually requires a two-person crew for single post replacement. One person serves as lookout while the other removes the broken stub, cleans out the existing hole, installs the new signpost and tamps the soil around the post.

Cost estimate:
0.75 hours x 2 persons = 1.5 person hour

1.5 person hour x $28 per hour = $42

**Number of Hits for Payback**

The unit cost of the QCSP footing itself is $100.
The installation cost of a QCSP footing is $91.
The total cost for an installed QCSP footing is $191.

A typical replacement cost for a wood post in the QCSP footing is $9.52

A typical replacement cost for a wood post in soil is $42

The difference in replacement costs is $32.48.

$191/$32.48 = 5.88

Therefore, after approximately six hits on a post installed in a QCSP concrete footing the replacement savings will pay for the initial installation costs. More importantly is the fact that the 35 minutes saved for each of those 6 replacements adds up to 210 minutes of time that 2 sign crew members are NOT on the roadway.

# Appendix F

State of California | Business, Transportation and Housing Agency

# Memorandum

To: MR. JAMES BORDEN
Program Manager
Traffic Operations

Date: February 26, 1997

File: F94TL31

From: **DEPARTMENT OF TRANSPORTATION**
New Technology and Research Program

Subject: Field Evaluation of a "Quick-Change" Sign Support System

The Facilities Research Branch of the Office of Research is nearing completion on a research project titled "Development of a Quick-Change Breakaway Sign Support System. This system is to be used as an alternative to installing small wood posts in augured holes in dirt. The objective of this project is to reduce hazardous exposure time for roadside sign crews by providing a method to remove and replace 4" x 4" and 4" x 6" wood sign posts in 10 minutes or less. This is accomplished by installing an 18" diameter pre-cast cylindrical concrete footing into an augured hole 48" deep. This footing has a shaped cavity 42" deep which uses two recycled plastic wedges to secure the post.

A series of knock down tests were conducted last October and November in the presence of sign crews from Districts 3, 4, and 10 to demonstrate the effectiveness of this new sign support system. In all of the tests, the sign crews were able to remove the broken sign post stub and install and new sign post in less than 10 minutes.

The 4" x 4" and 4" x 6" wood roadside sign posts which are installed in augured holes in soil have been extensively tested and are approved for use on California Highways. I feel confident that this new sign support system is equally as safe as currently installed roadside sign posts due to the much stiffer support provided by the concrete footing.

I would like to proceed with a proposed plan to install 12 each of these footings in Districts 3, 4, and 10 for a 6 month field test. The footings would be placed in locations which experience a high number of knock downs to allow the researchers an opportunity to evaluate the performance of this new design under field conditions. If the field test shows this to be a promising product, it would be implemented statewide for use at locations which are deemed either "high hit" or "very hazardous" by the individual districts.

JOHN WEST,
Program Manager,
New Technology & Research

I approve:

James Borden

JAMES BORDEN
Program Manager
Traffic Operations

3/6/97
Date

# Appendix G

**SPECIAL PROVISIONS**
Contract No. 11-244604
11-SD-5-R0.0/R116.5, T0.8/R125.2
(Section 10-1.15)

**10-1.15 __ SIGN POST SUPPORT SYSTEM**

Reinforced concrete sign post support system shall conform to the details shown on the plans and these special provisions. Sign post support shall be pre-cast.

Concrete for sign post support system shall be minor concrete, except that the concrete shall contain not less than 400 kilograms of cement per cubic meter.

Welded steel cavity, as shown on the plans, is the inner form of the sign post footing. Welded steel cavity form shall conform to the provisions in Section 75, "Miscellaneous Metal," of the Standard Specifications.

Sign post wedges shall be a strong, impervious to weather, dimensionally stable material, machined to the dimensions shown on the plans.

Gravel bag fabric shall be woven polypropylene, polyethylene or Polyamide with a minimum unit weight of 135 $g/m^2$. The fabric shall have a mullen burst strength of at least 2067 kPa, conforming to the requirements in ASTM Designation: D 3786 and an ultraviolet (UV) stability exceeding 70 percent.

Gravel bags, when filled, shall have nominal dimensions (length x width x height) of 400 mm x 300 mm x 150 mm, and a filled mass of 13 kg to 22 kg.

Gravel bag fill material shall be non-cohesive gravel, free from deleterious material.

The contract unit price paid for sign post support system shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in sign post support system, complete in place, including excavation and backfill, welded steel cavity form, sign post wedges and gravel bag, as shown on the plans, as specified in the Standard Specifications and these special provisions, and as directed by the Engineer.

* Dated: February 26, 2001