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Final Report

To Advance the Concept of Aesthetics and Constructability in the Design of Noise Barrier Walls Through the Design of Models, Prototypes, Plans and Specifications of the Bhavnani Design

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By The

NJIT Transportation Research Center

Year 2

December 17, 1999

NJIT
New Jersey Institute of Technology

A Public
Research University

NEWARK COLLEGE OF ENGINEERING
DEPARTMENT OF CIVIL AND
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December 21, 1999

Mark Marsella
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Bureau of Research and Demonstration
NJDOT
1035 Parkway Avenue
Trenton, NJ 08625-0600

Dear Mr. Marsella:

Enclosed please find the final report, "To Advance the Concept of Aesthetics and Constructability in the Design of Noise Barrier Walls Through the Design of Models, Prototypes, Plans and Specifications of the Bhavnani Design," dated December 17, 1999 in fulfillment of our research project with the NJDOT.

The research project demonstrated the aesthetic values of the Bhavnani design and the feasibility of the new attachment system. We look forward to working with you on the implementation of the new attachment system.

If you have any questions please feel free to contact us.

Best regards,

Walter Konon

Ed Dauenheimer
Eugene Golub
Walter Konon

Enclosure

EG/mb

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16. Abstract

The project is an approach to create a more pleasing roadway environment for drivers as they pass through areas shielded by noise barrier walls by installing shadow creating fins which produce a dynamic shadow play on the wall surface.

The front and back panel to post attachment system and the shadow creating fins produce a varied and more pleasing roadway environment which responds to complaints by the public about the aesthetics of current noise walls.

A prototype wall 18 ft. high by 45 ft.long was built and erected and is available to planners, designer and contractors to look at in full scale.

The shadow creating finds can be attached to any new concrete panel wall at an estimated cost of $10/ft. of fin ($33/m. of fin) installed.

The front and back panel to post attachment system using T bolts is reliable, easy to install, provides for increased field post placement tolerances, and eliminates the need to caulk H post joints. This system (using stainless steel T bolts and channels) can be installed for an estimated additional cost of $2/sq. ft. ($21.50/sqm.) of wall.

The prototype developed wall is viable and should be considered for use in limited stretches for visual relief and to highlight special locations. When used this way the prototype developed wall system could significantly improve aesthetics with little increase in the overall cost of a noise wall.

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Acknowledgments

This research was based on a concept conceived by Ashok Bhavnani who proposed the use of fins to create an aesthetically pleasing shadowplay pattern on the roadside surface of noise barrier walls.

The project researchers would like to thank Ashok Bhavnani and all the members of the advisory committee for their interest, contributions and ideas which played a significant role in the development of the prototype wall design. We would also like to single out Mark Marsella and Dominick Billera of the NJDOT for their encouragement and project support.

The researchers also thank Dr. Louis Pignataro of the NJIT Transportation Research Center for his vision and commitment to the project.

Finally we would like to thank Concrete Safety Systems who cast and erected the prototype wall free of charge as their contribution to the research project and Bob Hess and Clarence Mauser who made important practical suggestions during the design, production and erection stages of the prototype wall.

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SUMMARY AND CONCLUSIONS

The project is an approach to create a more pleasing roadway environment for drivers as they pass through areas shielded by noise barrier walls by installing shadow creating fins which produce changing shadow patterns on the wall surface. The fin pattern is created by bolting individual fins on the panel surface. The horizontal metal fins project 1 ft (0.3m) from the wall panel face and are positioned at 2 ft. (0.6m) intervals. The erection of panels into wall segments with differently configured horizontal fins creates a limitless variety of wall patterns. Depending on the sun's angle and intensity the length and definition of the shadows change which adds to the visual variety.

A prototype wall 18 ft. high by 45 ft. long (5.5m high by 13.7m long) was built and erected and is available to planners, designer and contractors to look at in full scale.

The front and back panel to post attachment system and the shadow creating fins produce a varied and more pleasing roadway environment (Figs. 29-34, page 32-34) which responds to complaints by the public about the aesthetics of current noise walls.

The shadow creating fins can be attached to any new concrete panel wall at an estimated cost of $10/ft. of fin ($33/m of fin) installed.

The front and back panel to post attachment system using T bolts (Fig. 9-10, page 22) is reliable, easy to install, provides for increased field post placement tolerances, and eliminates the need to caulk H post joints. This system and channels) can be installed for an estimated additional cost of $2/sq. ft. ($21.50/sqm) of wall over that of a conventional H post wall.

The prototype developed wall is viable and should be considered for use in limited stretches for visual relief and to highlight special locations such as exits and rest areas. When used this way the prototype developed wall system could significantly improve aesthetics with little increase in the overall cost of a noise wall.

RECOMMENDATIONS

The prototype developed wall is viable and should be considered for use in limited stretches for visual relief. This could significantly improve aesthetics with little increase in the overall cost of a noise wall. It is recommended that 300m (1,000 ft.) of a noise barrier wall be selected and built following the prototype wall design of front to back panel to post attachment with stainless steel hardware and shadow creating fins. This field test section would be used to evaluate aesthetics and public response, and roadway erection costs and procedures.

The metal shadow creating fins can be attached to any new concrete panel wall at an estimated cost of $10/ft. of fin ($33/m of fin). The cost could be reduced by the use of plastic fins, but the cost and reliability of plastic and other lower cost materials needs further study. Fins could also be attached to existing concrete panel noise barrier walls but at a higher cost.

The front and back T bolt panel to post attachment system hardware (channels, T bolts) costs are partially offset by panel erection cost savings. The channels and T bolts used in the prototype, however, were galvanized steel and would be subject to corrosion. Use of stainless steel channels and T bolts would eliminate the corrosion problem but would add an estimated $2/sq. ft. ($21.50/sq.m) of wall to the cost of the wall.

The exposed look of the bolt/washer/nut post to panel assembly on the surface of the panel (Figs. 10, 32, page 22, 33) as installed may be viewed as objectionable. A recessed slot cast in the panel to contain this assembly, which would be covered by a plastic plug or cement mortar, as well as other less noticeable options need to be considered.

INTRODUCTION

The purpose of the research conducted in the second year of the study was to demonstrate the feasibility of building a full scale prototype noise barrier wall that incorporated the aesthetic qualities developed in the design report Type II Noise Wall Study by Bhavnani. That proposed barrier design was developed for NJDOT to respond to complaints by the public about the aesthetics of barrier walls in current use.

The design incorporates the use of horizontally projecting shadow creating fins. The fins project 1 ft. (0.3m) from the wall panel face and are positioned at 2 ft. (0.6m) intervals with the first fin located 8 ft. (2.4m) from ground level. The lower 8 ft. (2.4m) finless section of the wall can be protected by landscaping and other anti-graffiti measures. The erection of panels into a wall segment with differently configured horizontal fins creates a limitless variety of wall patterns. A dynamic shadowplay is produced by sunlight casting the fin shadows on the wall plane surface. Depending on the sun's angle and intensity, the length and definition of the shadows change and adds to the visual variety (Figs. 29-34, page 32-34). The one-third scale model wall built at NJIT during the first year of the study used plastic fins to demonstrate the visual effect of the shadowplay. However, further studies on the present structural reliability of recycled plastics and the high cost of extruded virgin plastics required the use of metal powder coated fins for the prototype.

In addition to aesthetic considerations the research conducted by NJIT also focused on the attachment systems for panel to post connections. Currently used concrete H post and panel systems require precise vertical and horizontal positioning of posts which can lead to field erection tolerance problems. The goal was to develop a system that was reliable, easy to install and which increased post placement tolerances in the field.

STUDY PROCEDURE

The full scale prototype wall designed by NJIT consisted of 3 sections of wall panels producing a wall which was 45 ft. long by 18 ft. high (5.5m high by 13.7m long). This length of wall was chosen to demonstrate the aesthetic possibilities of creating distinct visual shadow patterns and to gain an understanding of casting and field erection requirements. The fin pattern selected for the prototype was a butterfly shape (App. Dwg. 4, page 53). Numerous methods of creating the horizontal shadow casting fin projections were considered. Casting the concrete fin as an integral part of the concrete panel was one option. This option provided additional structural stiffness to the concrete panel with the possibility of having longer panels with a wider post spacing. Difficulties with concrete casting, shipping problems, and the need to cast many different panels each with a different fin size and location on the panel worked against this option. Another option was the use of extruded plastic fins which would be attached to the surface of the panel at the field site. This allowed for the use of standard concrete panels that would be used as a canvas on to which the fins would be attached to create a predetermined design pattern. That option was pursued and used in the 1/3 scale model built in 1997. The cost of using structurally reliable plastics, however proved to be prohibitive. Recycled plastics were less expensive but were not structurally reliable in the thin shapes needed for the fins. Ultimately a steel fin with a baked powder coated finish was selected as the most reliable and cost effective method of producing the desired shadow pattern on the surface of the wall. The fins were bolted on the surface of the panel in the field to produce the designed fin pattern.

The panel to post attachment system developed by NJIT and used in the 1/3 scale model had the face planes of succeeding wall segments offset and attached to the front or back of posts. The panels were lag bolted into a plastic nailer embedded in the posts. In response to lessons learned from the model and input from the advisory board additional panel to post attachment systems were evaluated. The use of a T bolt system attaching to an embedded steel channel in the post was selected for use in the full scale prototype. A metal angle bolted attachment system being used for the first time on a NYSDOT noise barrier wall was also studied and evaluated during field panel to post installation.

On June 12, 1998 the NJIT noise wall team visited the site of a NYSDOT noise wall at exit 34 on the Northern State Parkway (NSP) on Long Island. The noise wall contractor and general contractor was Yonkers Construction. The noise wall panels and posts were supplied by Concrete Safety Systems (CSS). The concrete noise wall being erected used a front and back panel system (same as the NJIT prototype) attached to the posts by a newly developed bolted angle attachment system (Fig. 35A-D, page 35-38). The NSP wall had posts on 12 ft. (3.7m) centers with varying panel heights ranging up to 8 ft. (2.4m) high and with a standard panel length of 14 ft. (4.3m). Maximum wall heights was 16 ft. (4.9m) high.

The panels were lifted into position by a 35 ton hydraulic crane and attached by placing the galvanized angle into a slot in the post. The two bolts in the angle were then attached to two bolt anchors at the panel end (Fig. 39, page 40). Once both sides of a panel were attached by this method the panel became fixed on the posts. The sequence of erection for the NSP job is shown on the Figs. 36-47, (page 39-44). As reported by the Yonkers project manager a crew of 6 men was typically used to install the panels (1 crane operator, 1 labor foreman, 4 laborers). This crew after a break-in period could place 7 bays per day (14 panels) of the maximum size panels used of 8 ft. (2.4m) high. This produced a total of ,568 sq. ft. (146 sqm.) of panel erected per day (7 hours). Both the prototype wall and NYSDOT metal angle bolted wall were studied to determine erection procedures and costs.

RESULTS AND DISCUSSION

Prototype Design

The reinforced, air entrained, 5,000 psi (34.47M Pa) concrete panels were designed to be 5 inches (12.7cm) thick, 17 ft. (5.2m) long and, 2 ft. (0.6m) or 4 ft. (1.2m) high (App., Dwg. 2, page 51). A 6-3/4 inch (17.1cm) long tapered slot hole was cast into the panels 1 ft. (0.3) from each panel end to accommodate the T bolt during panel erection. This slotted hole provides for a ±3 inch (7.6cm) horizontal tolerance for misaligned posts.

The surface texture selected for the highway side (fin side) of the wall was a bush hammer finish. A fuzzy rake finish was selected for the residential side of the wall. The 4 ft. (1.2m) high panel shown in App. Dwg. 3, page 52 is intended for attachment to the post from the highway side and as such has a 2 ft. (0.6m) wide flat buff finish on each end of the residential side surface to allow for flush placement against the post. Not shown in the design drawings is the residential side attachment panel which requires a 2 ft. wide flat buff finish on the highway side with a full 17 ft. (5.2m) wide fuzzy rake finish on the residential side.

A horizontal row of 3/8 inch (1cm) diameter Fosroc plastic anchors with a working load of 1,300 lbs (5,782N) per anchor was cast into the panel surface at 1 ft. (0.3m) centers for fin attachment as shown in App., Dwg. 1 and 2, page 50 and 51. As designed it was envisioned that all highway side panels would have fin anchors installed even though no fins would be attached on the bottom 8 ft. (2.4m) of the wall.

The reinforced, air entrained, 5,000 psi (34.47M Pa) concrete posts measuring 18 inch by 18 inch (46cm by 46cm) and 24 ft. (7.3m) long were designed to be placed at 15 ft. (4.6m) centers to support the panels. The posts as built had a flat finish on all four sides. The side surfaces of the posts which are exposed to highway view could be manufactured with a textured surface to improve aesthetics. The top of post height was set 4 inches (10cm) below the top of the panels (as shown in App. Dwg. 5, page 54) to allow for a ±4 inch (10cm) tolerance in post or panel height placement, before the top of the post becomes visible above the top of the panels.

Post foundations consisted of concrete encased posts. Shims were placed on top of the concrete post encasement to level out the bottom panel.

A 20 ft. (6.1m) long Halfen, 3817 HTA - HT 3100 anchor channel (App. page 59) was cast into the front and rear face of each post as shown in App. Dwg. 8, page 57. These channels provide the anchorage for the Halfen MI6 (5/8 inch (16mm) diameter) T bolts which attach the panel to the post. The channel has an allowable pullout capacity of 1,375 lbs. (6,116N) which is well above the maximum design wind load of 40 lb/sf (1.92k Pa) which produces a 700 lbs. (3,113N) loading per bolt.

The panel to post attachment is made by installing the T bolt through the slotted hole in the panel. The T bolt is then turned 90° which locks the T head in the channel. Steel washers and nuts are then screwed on the T bolts to make the connection. The possible need for an enlarged washer to more effectively transfer wind loads at the bolt/washer/slot interface requires analysis and testing which was beyond the scope of the project. For the prototype all Halfen channels and bolts were made of galvanized steel. They are available in stainless steel.

The steel fins which attach to the plastic anchors in the panel face were made of 14 gauge steel with a powder coated tan color finish. The fins protrude 10-3/8 inches (26cm) from the surface of the panel and are attached to the panel by 3/8 inch (1cm) diameter stainless steel bolts. The fins were manufactured by Industrial Acoustics Company (IAC) as shown on App. Dwg. 330083-1, page 58.

Panel and Post Casting

The concrete panels and posts for the prototype wall were cast at the Concrete Safety Systems (CSS) plant in Pennsylvania. The CSS Company provided critical support to the project with their design advice and by casting and erecting the prototype wall free of charge.

The panels were cast in a horizontal position with standard bush hammer form liner on the bottom surface of the forms and with an open fuzzy rake finish on the top. Location of the plastic fin anchors on the bottom of the form was accomplished by using anchor plugs attached to the bottom of the form set at 1 ft. (0.3m) centers. This operation required little additional work during casting and went smoothly. There were a total of eight 4 ft. by 17 ft. (1.2m by 5.2.m) and two 2 ft. by 17 ft. (0.6m by 5.2m) highway side and four 4 ft. by 17 ft. (1.2m by 5.2m) and one 2 ft. x 17 ft. (0.6m by 5.2m) residential side panels cast to make up the prototype wall.

The posts were also cast in a horizontal position using modified standard H post forms. There were four 24 ft. (7.3m) long posts cast for the prototype wall. All panels and posts were cast at the CSS plant in April and May of 1999. Details of the casting are shown in Fig. 1 thru 6, pages 18-20.

Post and Panel Erection

The posts were erected at the rear of the CSS site and positioned so that the highway side of the wall faced east to catch the morning sun. Post erection followed the same installation procedure as standard H post erection would require with; excavation, post positioning, and casting the post in the excavated hole in concrete.

Panels for the prototype wall were erected on June 3, 1999 by a crew of CSS maintenance employees, using a 20 ton hydraulic crane with an 80 ft. boom. The crew consisted of two men who attached the fins and who erected the panels and one crane operator.

Panels were pre-positioned near the wall location within reach of the crane and were lifted into position and T bolted in place on the posts. A typical 4 ft. by 17 ft. (1.2m by 5.2m) panel which required the attachment of 2 fins and placement of 4 T bolts took 15 minutes to install from start to finish. This broke down to 10 minutes to install the fins and 5 minutes to swing lift and install the panel.

A total of twelve 4 ft. (1.2m) panels and three 2 ft. (0.6m) panels ((a total of 918 sq. ft. (85.3sqm) of panel)) including the attachment of 136 lin. ft. (41.5m) of fins took the 3 man crew 3-1/2 hours to complete. This was extremely fast especially considering the fact that the system was new and untried and the fact that the CSS maintenance crew does not normally do wall erection. One difficulty encountered was that some of the plastic fin anchors had some grout in them. This required them to be cleaned with a tap (Fig. 13, page 24). During actual production of this type of panel the plastic anchor holes would all be cleaned with a tap prior to shipment to the site. This cleaning requires 2 minutes for one man per 4 ft. (1.2m) panel. The sequence of wall panel erection for the prototype wall is shown in Figs. 7 thru 26, pages 21-30).

A second problem which was observed during fin installation was fin edge warping (Fig. 18, 20, page 26, 27). This was caused by panel surface unevenness where the metal fin rear attachment edge sits on the concrete panel surface.

However, the problem was not noticeable when viewing the wall from a driver's perspective (Fig. 31, page 33). The problem could be eliminated by placement of a leveling gasket on the rear attachment edge of the fin.

Fin Aesthetics

Sound barrier walls combat noise pollution in adjacent neighborhoods, but also obscures the landscape we all enjoy viewing while driving. Existing walls are often perceived as having a monotonous unattractive appearance.

The fin wall design is based on a concept developed by architect Ashok Bhavnani in 1994 for the NJDOT. The design concept incorporates shadow creating fins. The erection of panels into wall segments with differently configured horizontal fins can create a limitless variety of wall patterns. A dynamic shadowplay is produced by sunlight casting the fin shadows on the wall plane surface. Depending on the sun's angle and intensity, the length and definition of the shadow changes and adds to the visual variety. The prototype wall butterfly fin design changing shadow pattern can be seen in photographs taken at 8:30 am Figs. 30-32, (page 32, 33) at noon Figs. 33-34 (page 34) and at 1:30 pm Fig. 29 (page 32). The wall has an eastern exposure on the fin side.

Horizontal and Vertical Alignment Changes

Horizontal alignment changes in the prototype design wall can be best accomplished by casting special angled columns which would then maintain the ±3 inch (7.6cm) tolerance on horizontal post placement. This would produce full panel to post contact on the post surface which would reduce any possibility of noise leakage at panel to post openings. An alternate method could employ plastic wedges with a slotted hole placed between the post and panel and the use of wedged washers on the panel face as shown in Fig. 48, page 45. The as built prototype was a straight section of wall and as such design and construction details for horizontal alignment changes could not be evaluated.

Vertical alignment changes would be accomplished at the top of the wall by casting a slope at the top of a panel. Elevation changes of less than 9 inches (23cm) would be via a 2 ft. (0.6m) form. Elevation changes of up to 2 ft. - 9 inches (84cm) would be via a 4 ft. panel (1.2m) (Fig. 49, page 46).

Changes in vertical alignment at the bottom of the wall would be accomplished by ft. (0.3m) or 2 ft. (0.6m) high panels (fig. 49, page 46).

<u>Corrosion</u>

Fins - The steel fins used in the prototype wall were manufactured with a baked on powder coating finish which provides the currently available best corrosion paint protection finish. Individual fins installed in the prototype wall experiencing corrosion could be replaced. The use of non corroding fins (e.g., plastic) needs to be further explored and developed. The fin anchors are plastic and do not corrode. The fins are attached to the plastic anchors by 3/8 inch (1cm) diameter stainless steel bolts and stainless steel washers and should not present a corrosion problem.

Panel to Post Attachment - The Halfan channels and Halfan T bolts used in the prototype were both made of galvanized steel and will eventually corrode. Both channels and T bolts are available in stainless steel but at a cost of four times the cost of the galvanized steel.

Noise Abatement

In conventional H post and panel construction, tolerances must be provided on the H post slots so that the panels can be slipped in. This produces open noise paths which reduces the noise abatement effectiveness of the system. Typically backer material and caulk are used to seal these tolerance openings which add to the overall construction cost of the H post system. With thermal movement over time the backer material and caulk often come loose and need maintenance work.

The front and back bolted attachment system used in the NJIT prototype wall provides a positive flush contact between panel and post and eliminates the need to seal tolerance openings and by so doing eliminates caulking costs.

Cost Analysis

It should be noted that due to the front and back attachment system used in the prototype wall the sq ft. area of the panels was 18 ft. x 17 ft. (5.5m x 5.2m) x 3 918 sq ft. (85sqm), while the actual area of the wall was 18 ft. x 45 ft. (5.5m x 13.7m) = 810 sq ft. (75sqm). In comparing costs of the prototype wall to other walls it is important to know if $/sq. ft. of wall or $/sq. ft. of panel is being used in the comparison. The NSP wall contractor reported being paid by NYSDOT on a $/sq. ft. of panel basis.

The cost of the prototype system is examined in two separate categories Fin Costs and Post to Panel Attachment Costs.

Fin Costs

For the butterfly pattern used in the prototype wall the additional cost of all materials and construction site installation came out to be $1.91/sq. ft. ($20.55/sqm) of wall or $11.35/lin ft. of fin ($37.23/m) (Fig. 50, page 47).

The fins can be attached to a conventional H post and panel system just as easily as they were attached to the prototype wall panels. It is estimated that to attach fins to any new concrete wall panel with reductions for mass production of fins, would cost $10/lin ft. of fin ($33/m) installed.

Panel Attachment Costs

The cost of panel to post attachment in the field for the prototype system is difficult to estimate due to the wide variety of conditions encountered in the field during installation.

The prototype wall erection work was done by a small, efficient crew on a short section of straight wall on flat terrain. For these conditions it is estimated that construction site erection costs for the panels would be $0.35/sq. ft. ($3.77/sqm) of wall (Fig. 51, page 48). More difficult site conditions with larger crew requirements could raise the figure to $1/sq. ft. ($10.75/sqm) of wall. This cost does not include post placement, nor panel unloading, storage or site movement. It is clear that the prototype attachment system is simple and fast and could significantly reduce panel erection costs by an estimated $1/sq. ft. ($10.75/sqm) of wall.

Additional cost savings for the prototype wall system would be gained due to the increased post placement tolerances of the system with a reduction of post misalignment problems and the elimination of the need to caulk the H post joints with estimated savings of $1/sq. ft. ($10.75/sqm) of wall.

The prototype wall system does require additional expenditure for hardware (channels and T bolts). The additional cost is $1/sq. ft. ($10.75/sqm) of wall (Fig. 51, page 48). If stainless steel channels and bolts are used the cost is increased to $4/sq. ft. ($43/sqm) of wall. Therefore, with estimated erection and no caulking cost savings of $2/sq. ft. ($21.59/sqm) of wall and cost additions of $4/sq. ft. ($43/sqm) using all stainless steel hardware the prototype system can be installed for an estimated total additional cost of $2/sq. ft. ($21.50 sqm) of wall. This cost is the added cost over that of a conventional H post and panel noise barrier wall.

The NSP noise wall panel field erection cost was $1.74/sq. ft. of panel. This figure does not include the cost of the 4 galvanized angles, 8 galvanized bolts and 8 bolt anchors needed per panel for that system. The cost of this hardware was not available.

Fig. 1 Bush hammer (highway side) form liner at bottom of horizontal form at CSS.

Fig. 2 Bush hammer (highway side) 4 ft. panel with smooth end treatments which rest against the posts.

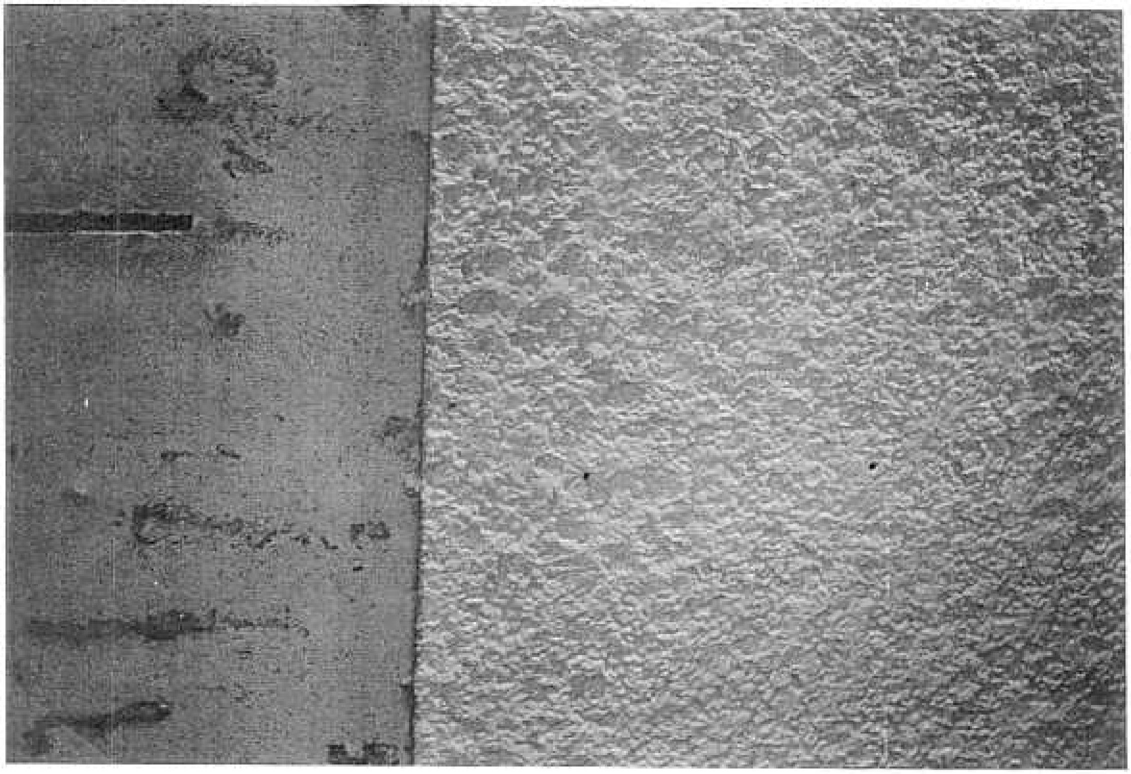


Fig. 3 Detail of Fig. 2 showing plastic fin anchor holes.

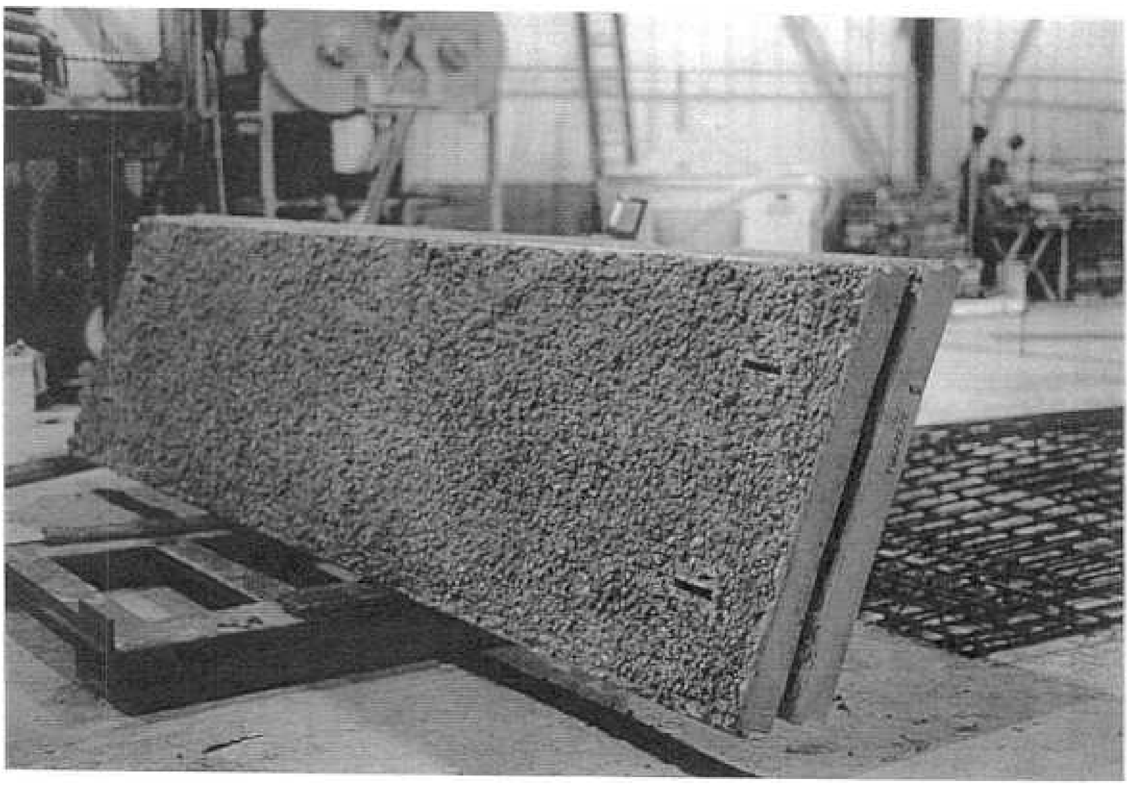


Fig. 4. Fuzzy rake finish on residential side of Fig. 2 panel.

Fig. 5. **Fuzzy rake finish (residential side) of 4 ft. panel with smooth end treatments which rest against the posts.**

Fig. 6. Concrete post - 24 ft. long with channel for T bolts cast in. Note: Halfan Channel on left.

Fig. 7 Prototype posts 4@15 ft. center at CSS yard.

Fig. 8 Panels stacked on rack ready for erection.

Fig. 9 Three 4 ft. bottom panels are in place.

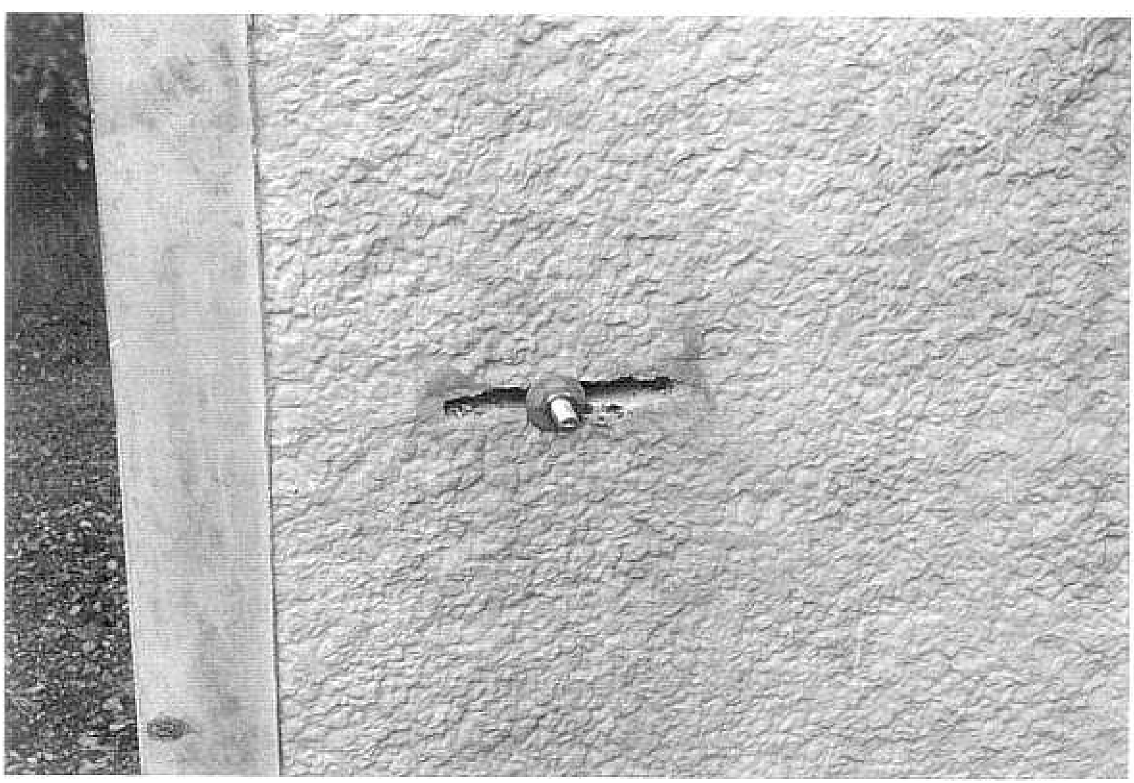


Fig. 10 Detail of T bolt in Fig. 9. Note slot mark at end of bolt to show T is set in channel.

Fig. 11 Residential side bolting of panel.

Fig. 12 Detail of Fig. 11, T bolt

Fig. 13 Grout filled plastic anchors needed **tapping**

Fig. 14 Fin attachment to panels.

Fig. 15 Four ft. panel with four 2 ft. fins.

Fig. 16 Panel Fig. 15 being bolted from the residential side with the bush hammer side to the post.

Fig. 17 Detail Fig. 16.

Fig. 18 6 ft. fin above 4 ft. fin shows some edge waviness.

Fig. 19 Same panel as Fig. 18.

Fig. 20 8 ft. and 10 ft. fins being attached.

Fig. 21 Checking panel edge for debris.

Fig. 22 Fig. 20 panel being lifted into position.

Fig. 23 Fig. 20 panel being lowered to posts.

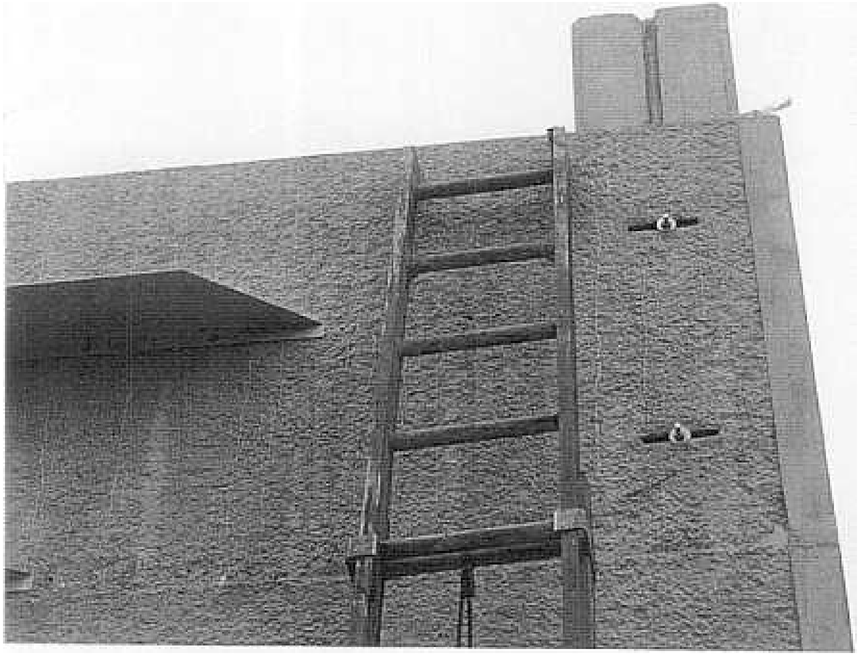


Fig. 24 Fig. 20 panel T bolt detail.

Fig. 25 12 ft. fin (6 ft. x 2) being attached.

Fig. 26 Fig. 25 - 2 ft. panel being bolted to post.

Fig. 27 Detail of T bolts on residential side.

Fig. 28 Residential side completed.

Fig. 29 Butterfly fin pattern on highway side
hazy sun at 1:30 P.M. - summer.

Fig. 30 Bright sun at 8:30 A.M. - summer

Fig. 31 Bright sun at 8:30 A.M. - summer
drivers perspective right lane.

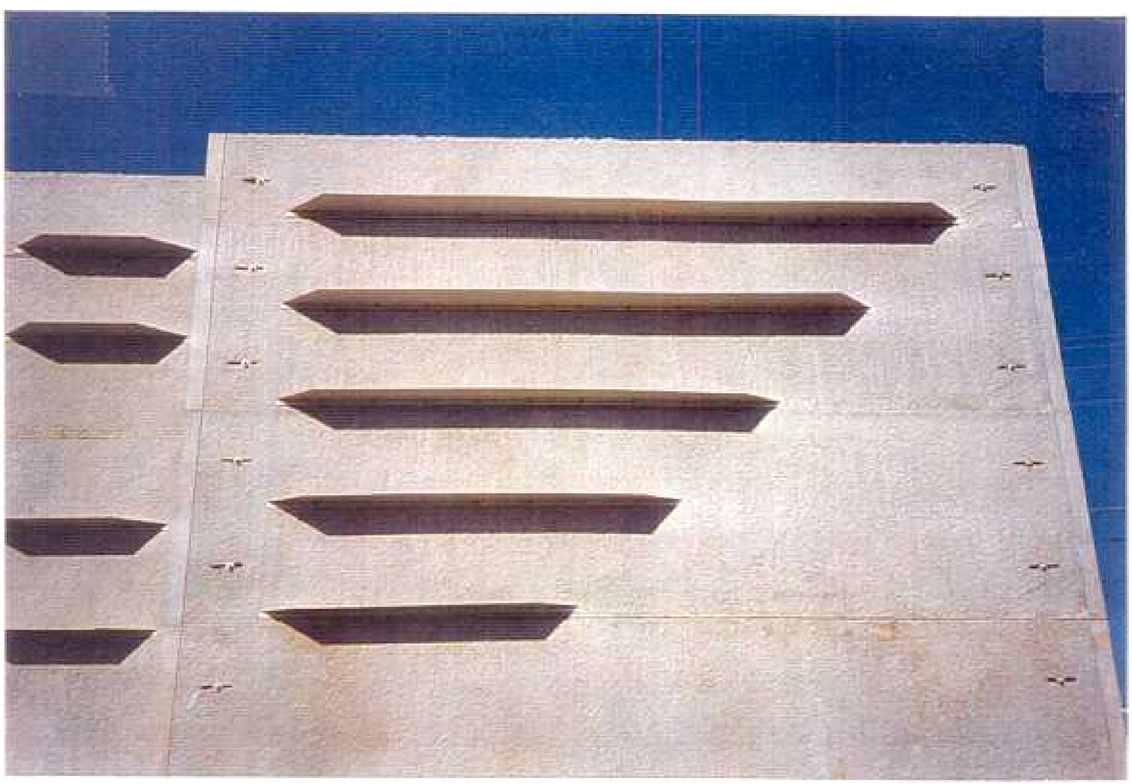


Fig. 32 Detail Fig. 31

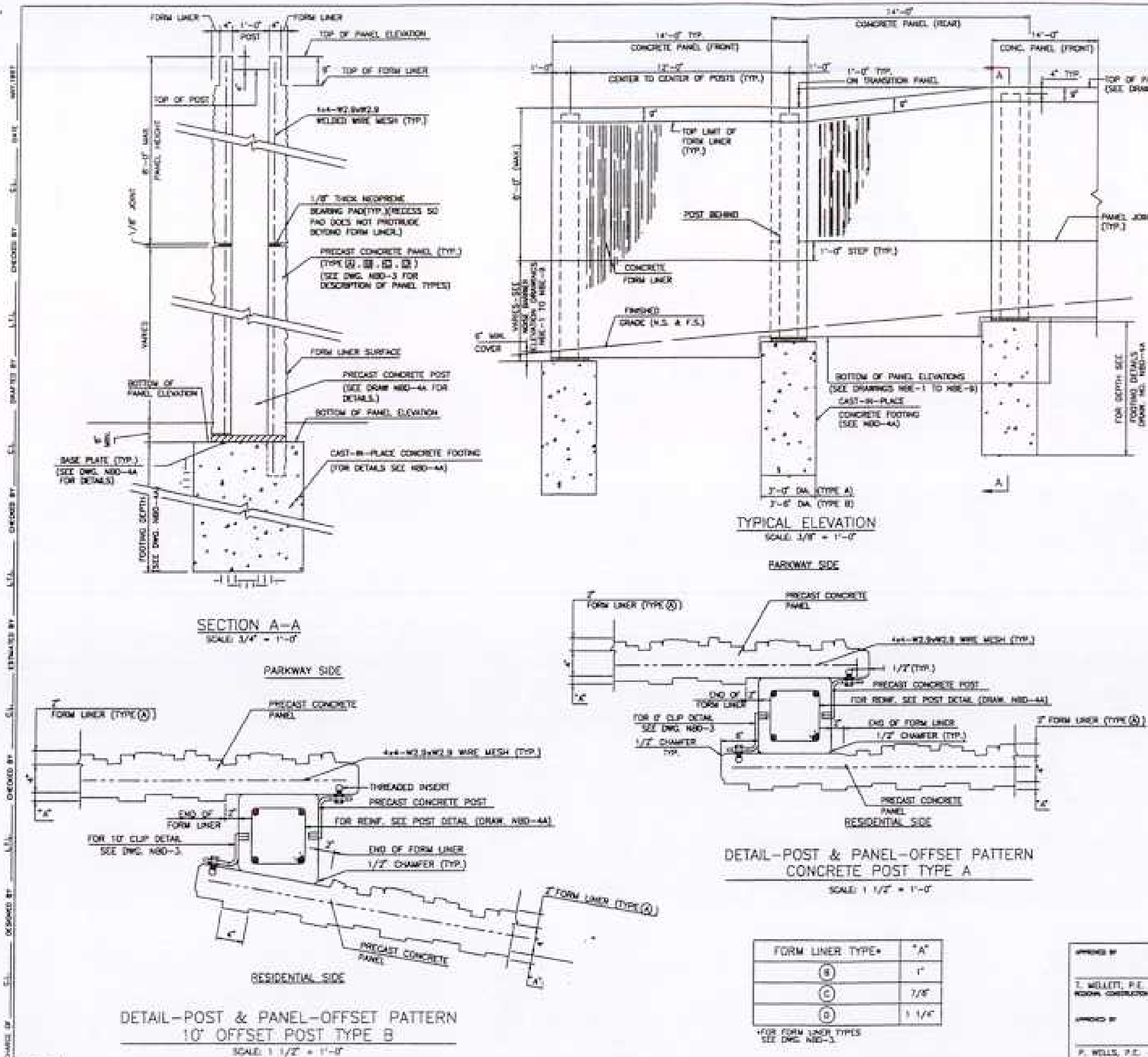
Fig. 33 Bright sun at 12 noon - summer.

Fig. 34 Bright sun at 12 noon - summer
drivers perspective right lane

D256495

FED. ROAD REG. NO.	STATE	FEDERAL AID PROJECT NO.	SHEET NO.	TOTAL SHEETS
1	N.Y.		230F1	696

NORTHERN STATE PARKWAY
MEADOWBROOK PARKWAY INTERCHANGE
TO WANTAGH PARKWAY INTERCHANGE
NASSAU COUNTY



FORM LINER TYPE*	"A"
(B)	1"
(C)	7/8"
(D)	1 1/4"

*FOR FORM LINER TYPES SEE DWG. NBD-3.

THIS SHEET SUPERSEDES SHEET 230 OF 696.

NOTES:

1. PAYMENT FOR ALL WORK SHOWN OR NOTED ON DRAWING NOS. NBD-1A, 1, 2, 3, 4A, 4B SHALL BE INCLUDED IN ITEM 10607.9902–CONCRETE NOISE BARRIER WITH ARCHITECTURAL FINISH.
2. FOR LOCATION AND GEOMETRY OF CENTERLINE OF POSTS SEE DRAWING NOS. NB-1 TO NB-7.
3. NOISE BARRIER DESIGNED FOR THE FOLLOWING LOADS:
   A. WIND: 34 P.S.F.
   B. SEISMIC HORIZONTAL ACCELERATION: 0.19g
4. 28-DAY COMPRESSIVE STRENGTH FOR CONCRETE (f'c) SHALL BE AS FOLLOWS:
   A. PRECAST CONCRETE (POSTS AND PANELS) = 5,000 P.S.I.
   B. CAST-IN-PLACE CONCRETE (FOOTINGS) = 3,000 P.S.I.
5. ALL STRUCTURAL STEEL SHALL MEET THE REQUIREMENTS OF ASTM A36 AND SHALL BE GALVANIZED IN ACCORDANCE WITH SUBSECTION 719-01.
6. STEEL BAR REINFORCEMENT SHALL MEET THE REQUIREMENTS OF ASTM A615, GRADE 60, UNLESS NOTED OTHERWISE.
7. UNLESS OTHERWISE SPECIFIED, ALL BOLTS, NUTS AND WASHERS SHALL MEET THE REQUIREMENTS OF ASTM A325.
8. NEOPRENE BEARING PADS SHALL BE INSTALLED AS SHOWN TO FIT TIGHTLY BETWEEN ADJACENT CONCRETE PANELS.
9. PRECAST CONCRETE PANELS SHALL HAVE CONCRETE FORM LINER ON EXPOSED SURFACES AS SHOWN ON DRAWING NBD-3.
10. TOPS OF POSTS AND TOP PANELS SHALL BE SLOPED TO DRAIN.
11. PRIOR TO ANY CLEARING AND GRUBBING IN THE VICINITY OF NOISE BARRIERS, THE CONTRACTOR SHALL FIELD SURVEY AND CLEARLY STAKE-OUT NOISE BARRIER ALIGNMENT. SURVEY AND STAKE-OUT SHALL ALSO INDICATE ALL SPECIMEN TREES SHOWN ON PLANS NOT TO BE REMOVED.
12. CONTRACTOR SHALL LAYOUT A PROPOSED ACCESS WAY TO CONSTRUCT THE NOISE BARRIER USING ORANGE SNOW FENCE. THE MAXIMUM WIDTH OF ACCESS WAY SHALL BE FIFTEEN FEET (15'). THE ACCESS WAY LAYOUT MUST BE APPROVED BY THE ENGINEER PRIOR TO REMOVING ANY VEGETATION AND TREES. THE ENGINEER MAY MAKE ADJUSTMENTS TO THE LOCATION OF THE ACCESS WAY IF, IN HIS OPINION, TOO MUCH EXISTING VEGETATION WOULD UNNECESSARILY BE REMOVED. THE FENCE IS TO REMAIN IN PLACE FOR THE DURATION OF THE PROJECT.
13. ALL VEGETATION WITHIN THE LIMITS OF THE APPROVED ACCESS WAY AS DELINEATED BY THE ORANGE SNOW FENCE MAY BE REMOVED AS NECESSARY BY THE CONTRACTOR.
14. NO VEGETATION AND/OR TREES OUTSIDE THE APPROVED LIMITS OF THE ACCESS WAY SHALL BE REMOVED WITHOUT PRIOR WRITTEN APPROVAL BY THE ENGINEER.
15. THE CONTRACTOR SHALL BE PENALIZED FOR ANY TREES REMOVED OUTSIDE OF THE APPROVED LIMITS. FOR EVERY CALIPER INCH OF TREE REMOVED WITHOUT THE ENGINEER'S PRIOR APPROVAL, THE CONTRACTOR SHALL:
   a. PLANT AN EQUAL NUMBER OF CALIPER INCHES OF NEW TREES OF THE SAME SPECIES AS THE ONE REMOVED. THE MINIMUM SIZE OF REPLACEMENT TREE WILL BE THREE (3") INCH CALIPER.
   b. PAY A FINE EQUAL TO ONE HUNDRED DOLLARS ($100.00) FOR EVERY CALIPER INCH OF TREE REMOVED.
16. ALL PRECAST CONCRETE POSTS AND PANELS SHALL HAVE A CONCRETE COLOR PIGMENT ADDED. ALL EXPOSED SURFACES SHALL BE FINISHED WITH AN ACRYLIC STAIN. FOR ADDITIONAL NOTES RELATED TO CONCRETE COLOR AND FINISH SEE DRAWING NBD-3.

AS-BUILT REVISIONS

SIGNATURE DATE

APPROVED BY
T. WELLETT, P.E.
REGIONAL CONSTRUCTION ENGINEER
APPROVED BY
P. WELLS, P.E.
DEPUTY CHIEF ENGINEER, CONSTRUCTION

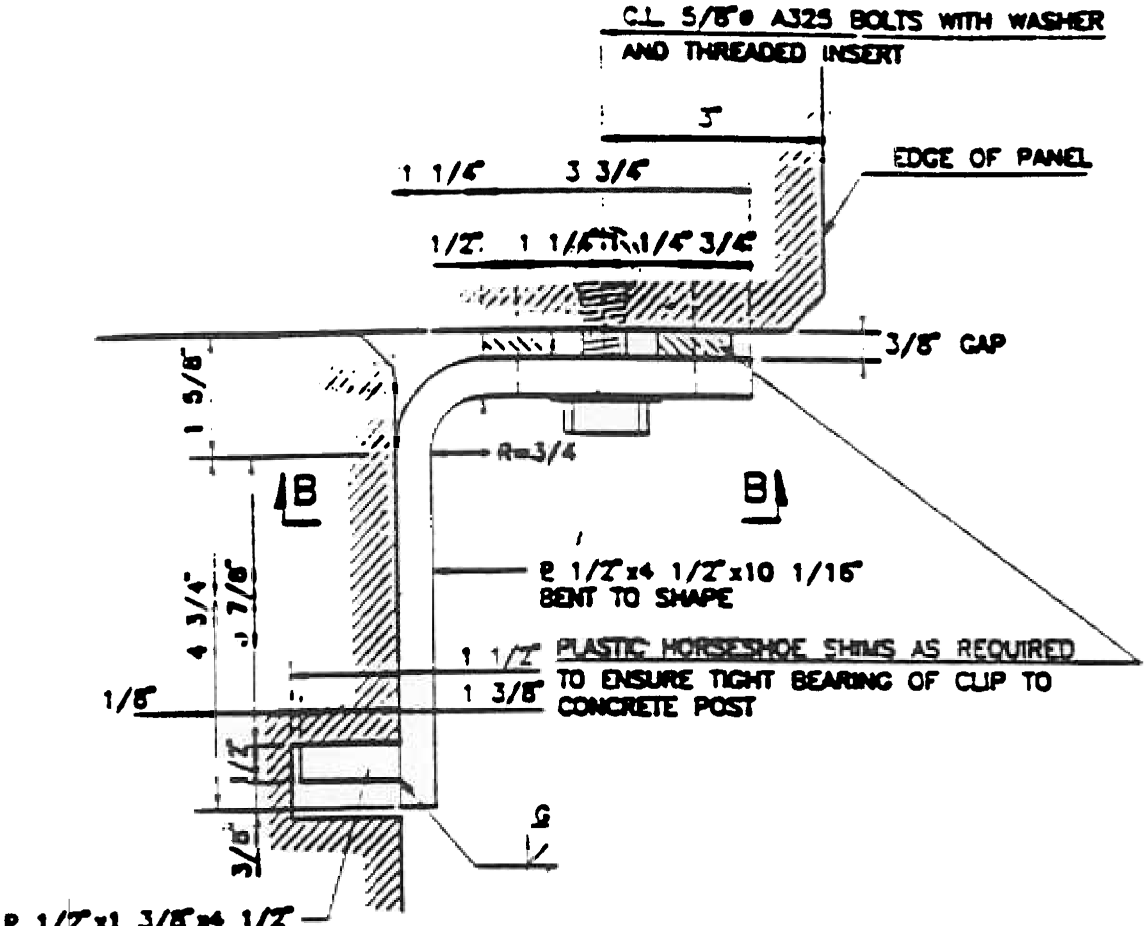
NOISE BARRIER DETAILS

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

DRAWING NO.	SCALE:	DATE:	
NBD-1A	AS NOTED	MAY, 1997	REGION 10

Goodkind & O'Dea, Inc.
Consulting Engineers and Planners

FIG 35 A

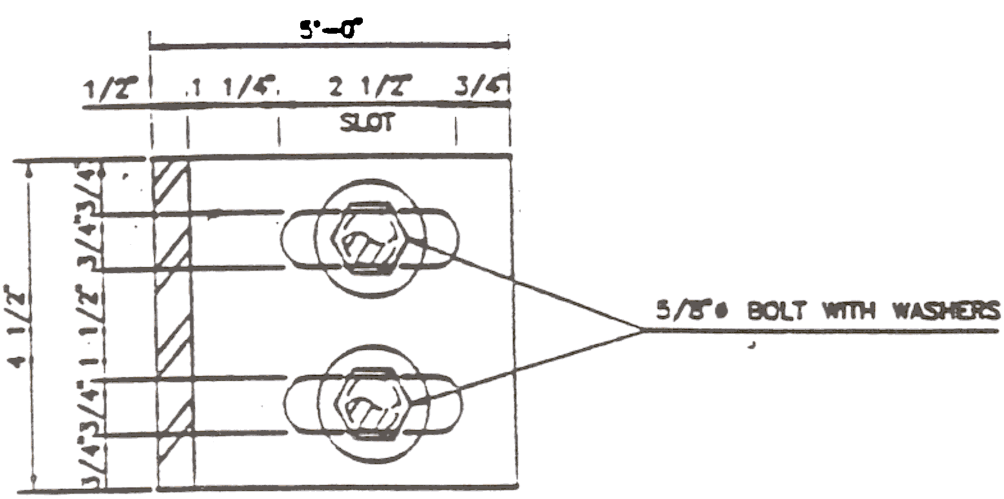


0° CLIP DETAIL (PLAN)

HALF SIZE

10° CLIP DETAIL (PLAN)

HALF SIZE



SECTION B–B (SHOWN)
SECTION B'–B' (SIMILAR)

HALF SIZE

NOISE BARRIER DETAILS

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

DRAWING NO.	SCALE:	DATE:	
NBD-4A	AS NOTED	MAY, 1997	REGION 10

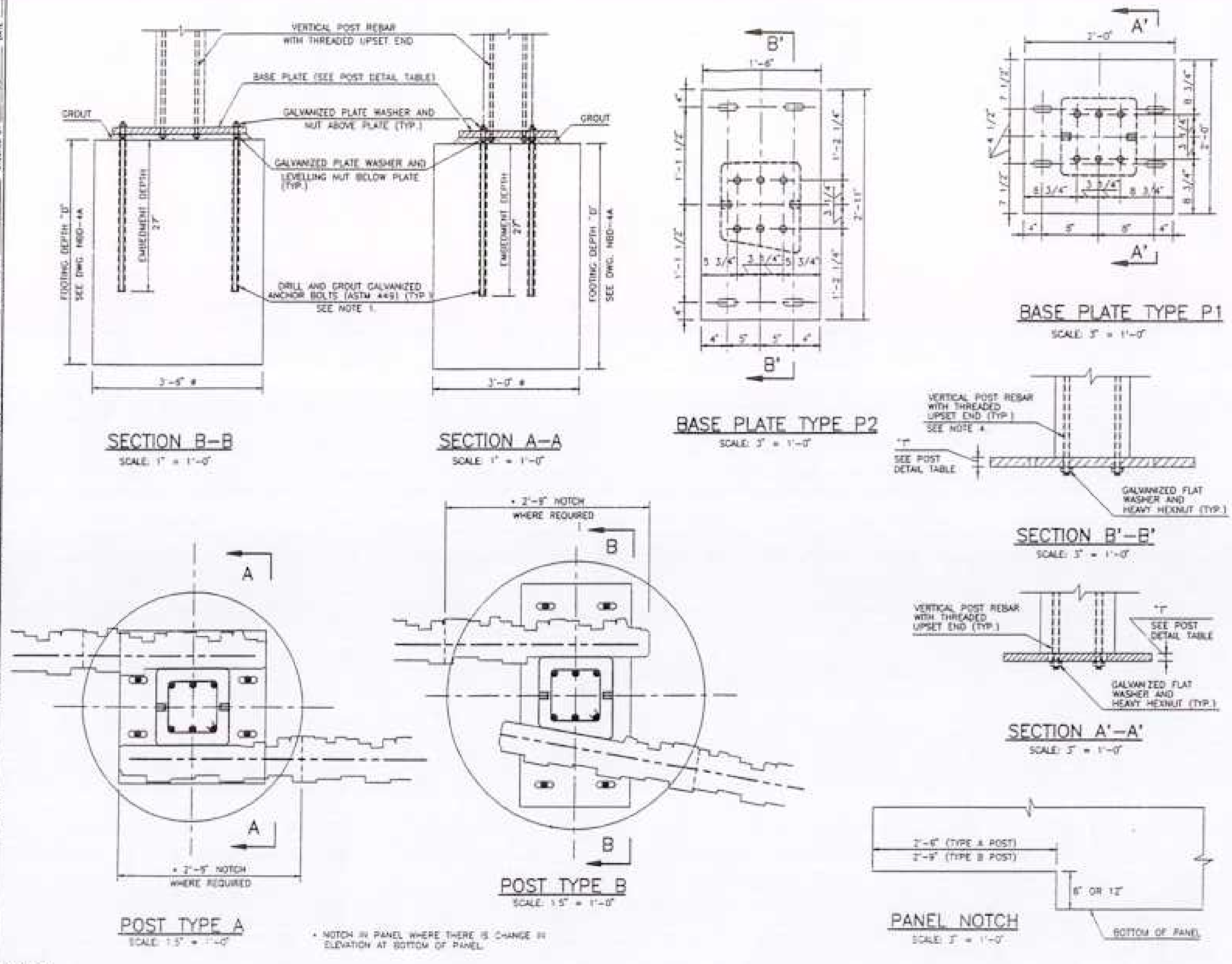
Goodkind & O'Dea, Inc.
Consulting Engineers and Planners

FIG 35

THIS SHEET SUPPLEMENTS SHEET 233F1 OF 696.

FED. ROAD REG. NO.	STATE	FEDERAL AID PROJECT NO.	SHEET NO.	TOTAL SHEETS
1	N.Y.		233F1	696

NORTHERN STATE PARKWAY
MEADOWBROOK PARKWAY INTERCHANGE
TO WANTAGH PARKWAY INTERCHANGE
NASSAU COUNTY



POST DETAIL TABLE

POST TYPE	BASE PLATE TYPE	PLATE THICKNESS (T)	ANCHOR BOLT DIAMETER
1A	P1	2"	1"
2A	P1	2"	1"
3A	P1	2"	1"
4A	P1	2"	3/4"
5A	P1	2 1/4"	1 1/4"
6A	P1	2 1/4"	1 1/4"
7A	P1	2"	1"
8A	P1	2 1/4"	1 1/8"
9A	P1	2 1/4"	1 1/8"
1B	P2	2"	3/4"
2B	P2	2"	3/4"
3B	P2	2"	3/4"
4B	P2	2"	3/4"
5B	P2	2 3/8"	7/8"
6B	P2	2 3/8"	7/8"
7B	P2	2"	3/4"
8B	P2	2 3/8"	3/4"
9B	P2	2 3/8"	3/4"

NOTE:

1. ANCHOR BOLTS AND GROUT SHALL BE MANUFACTURED BY KELKEN CONSTRUCTION SYSTEM OR APPROVED EQUAL. GROUT SHALL MEETS THE REQUIREMENTS OF NYS STANDARD SPECIFICATION, SECTION 701-07.
2. STEEL BASE PLATES SHALL MEET THE REQUIREMENTS OF ASTM 36 AND SHALL BE GALVANIZED IN ACCORDANCE WITH NYS STANDARD SPECIFICATION SECTION 719-01.
3. ALL NUTS AND WASHERS: SHALL BE ELECTRO GALVANIZED AND MANUFACTURED BY RICHMOND SCREW ANCHOR CO. OR APPROVED EQUAL.
4. VERTICAL POST REBAR WITH THREADED UPSET END SHALL MEET THE REQUIREMENTS OF ASTM A615 GRADE 60 AND MANUFACTURED BY RICHMOND SCREW ANCHOR CO. OR APPROVED EQUAL.

APPROVED BY
T. WELLETE, P.E.
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APPROVED BY
P. WELLS, P.E.
DEPUTY CHIEF ENGINEER, CONSTRUCTION

AS-BUILT REVISIONS

SIGNATURE DATE

NOISE BARRIER DETAILS

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

DRAWING NO.	SCALE	DATE	
NBD-4B	AS NOTED	MAY 1997	REGION 10

Goodkind & O'Dea, Inc.
Consulting Engineers and Planners

Fig 35

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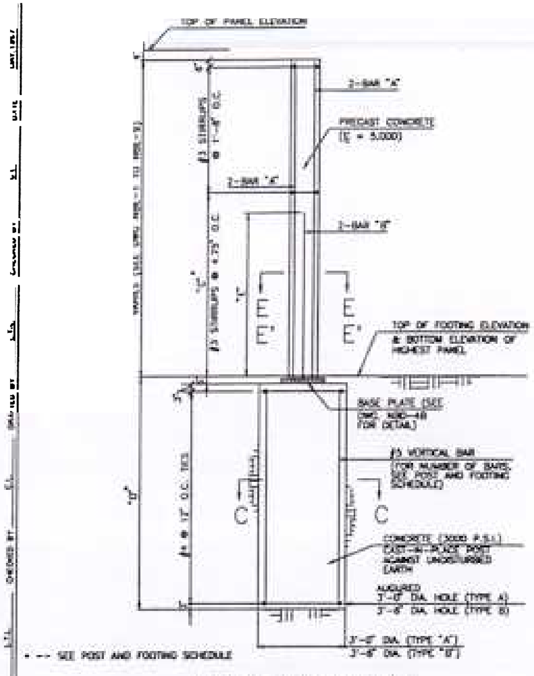
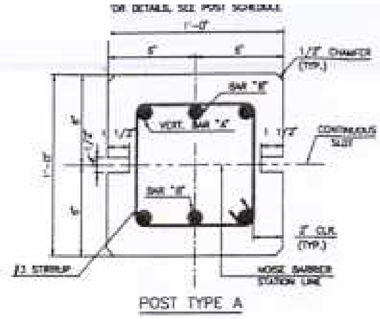
FED. ROAD REG. NO.	STATE	FEDERAL AID PROJECT NO.	SHEET NO.	TOTAL SHEETS
1	N.Y.		233F1	696

NORTHERN STATE PARKWAY
MEADOWBROOK PARKWAY INTERCHANGE
TO WANTAGH PARKWAY INTERCHANGE
NASSAU COUNTY

THIS SHEET SUPERSEDES SHEET 233 OF 696.

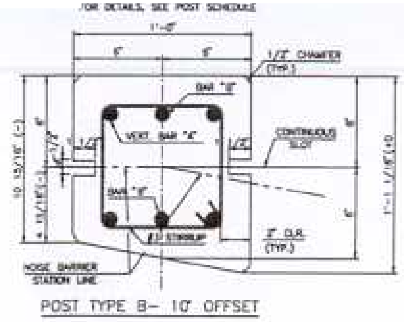


POST FOOTING–ELEVATION
SCALE: 1/2" = 1'-0"



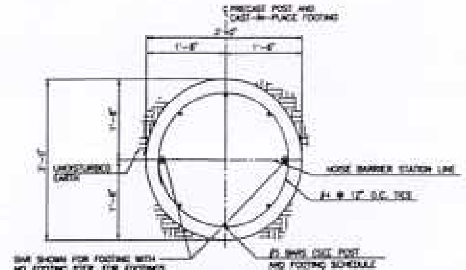
POST TYPE A

SECTION E–E
SCALE: 3" = 1'-0"



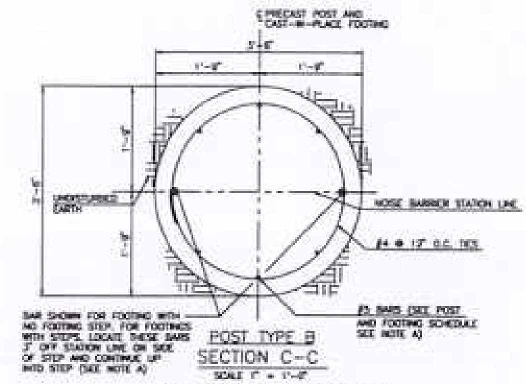
POST TYPE B– 10" OFFSET

SECTION E'–E'
SCALE: 3" = 1'-0"



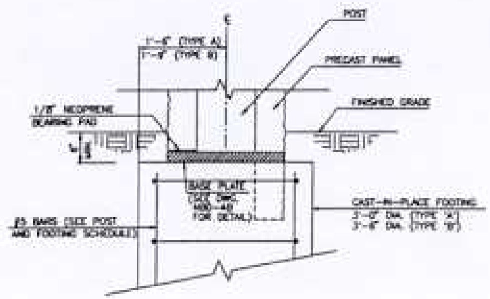
POST TYPE A
SECTION C–C
SCALE 1" = 1'-0"

NOTE A: ONLY 8 VERTICAL BARS ARE SHOWN.



POST TYPE B
SECTION C–C
SCALE 1" = 1'-0"

NOTE A: ONLY 8 VERTICAL BARS ARE SHOWN.



TYPICAL FOOTING STEP DETAIL
SCALE 1" = 1'-0"

POST AND FOOTING SCHEDULE

POST TYPE A (WITH 3'-0" DIA. FOOTING)

POST TYPE	"C"-POST STIRRUPS (POST)	BAR "A" (POST)	BAR "B" (POST)	"C" (POST)	"D" (FOOTING)	# OF VERT. REINF. (FOOTING)
1A	BOTTOM 3 FEET	#7	–	–	8'-0"	8
2A	BOTTOM 3 FEET	#7	#7	4'-0"	7'-0"	8
3A	BOTTOM 3 FEET	#7	#7	4'-0"	9'-0"	8
4A	BOTTOM 3 FEET	#8	–	–	7'-3"	8
5A	BOTTOM 6 FEET	#9	#9	6'-0"	10'-6"	16
6A	BOTTOM 6 FEET	#9	#9	6'-0"	8'-6"	16
7A	BOTTOM 3 FEET	#7	#7	4'-0"	10'-6"	8
8A	BOTTOM 4 FEET	#8	#8	5'-0"	11'-6"	12
9A	BOTTOM 4 FEET	#8	#8	5'-0"	7'-8"	12

POST TYPE B (WITH 3'-6" DIA. FOOTING)

POST TYPE	"C"-POST STIRRUPS (POST)	BAR "A" (POST)	BAR "B" (POST)	"C" (POST)	"D" (FOOTING)	# OF VERT. REINF. (FOOTING)
1B	BOTTOM 3 FEET	#7	–	–	8'-0"	8
2B	BOTTOM 3 FEET	#7	#7	4'-0"	7'-0"	8
3B	BOTTOM 3 FEET	#7	#7	4'-0"	9'-0"	8
4B	BOTTOM 3 FEET	#8	–	–	7'-3"	8
5B	BOTTOM 6 FEET	#9	#9	6'-0"	10'-6"	16
6B	BOTTOM 6 FEET	#9	#9	6'-0"	8'-6"	16
7B	BOTTOM 3 FEET	#7	#7	4'-0"	10'-6"	8
8B	BOTTOM 4 FEET	#8	#8	5'-0"	11'-6"	12
9B	BOTTOM 4 FEET	#8	#8	5'-0"	7'-8"	12

APPROVED BY
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APPROVED BY
P. WELLS, P.E.
DEPUTY CHIEF ENGINEER, CONSTRUCTION

AS-BUILT REVISIONS

SIGNATURE DATE

NOISE BARRIER DETAILS

NEW YORK STATE
DEPARTMENT OF TRANSPORTATION

DRAWING NO.	SCALE:	DATE:	
NBD-4A	AS NOTED	MAY, 1997	REGION 10

Goodkind & O'Dea, Inc.
Consulting Engineers and Planners

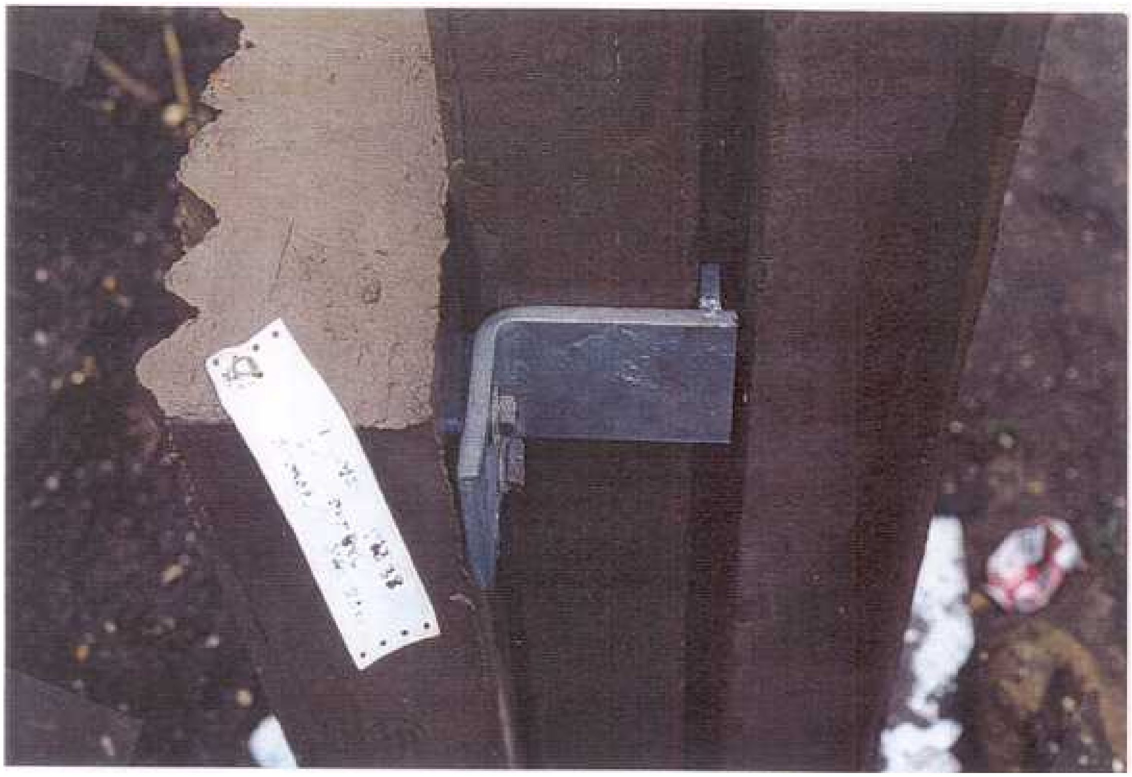
FIG 3!

Fig. 36 NSP noise wall panel erection.

Fig. 37 Detail of angle and bolt post to panel attachment.

Fig. 38 Detail of Fig. 31

Fig. 39 Detail of angle and bolt attachment



Fi 40 Deta igl bol tach

F Angl bott ind top of iel

Fig. 42 Note shims used between angle and panel.

Fig. 43 Panel bolt holes at lower right.

Fig. 44 Anchor bolts for post base plate.

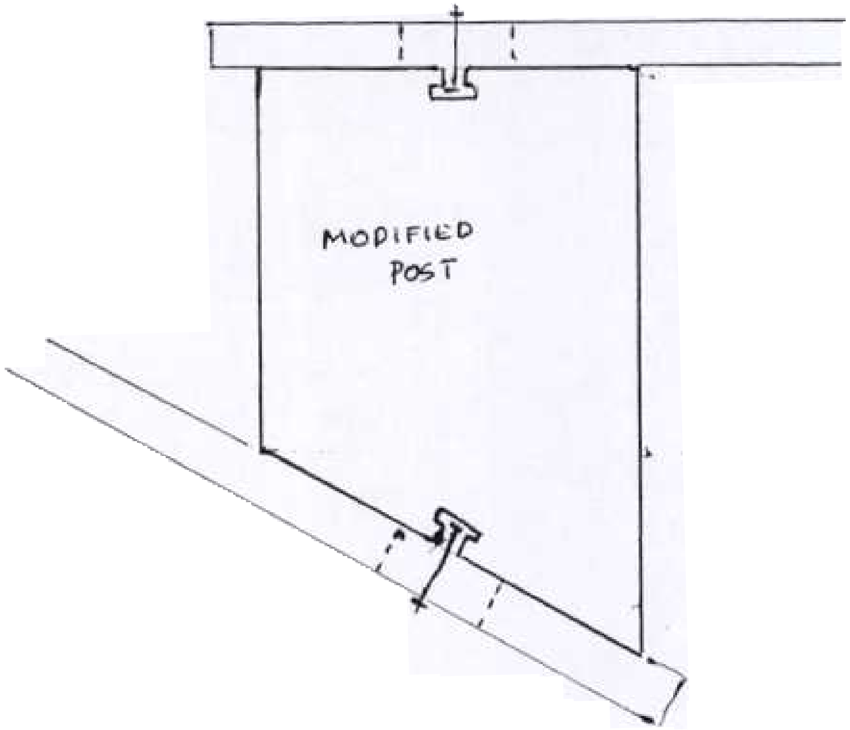
Fig. 45 Post base plate set on anchor bolts with grout below. Note anchor bolt and panel angle interference.

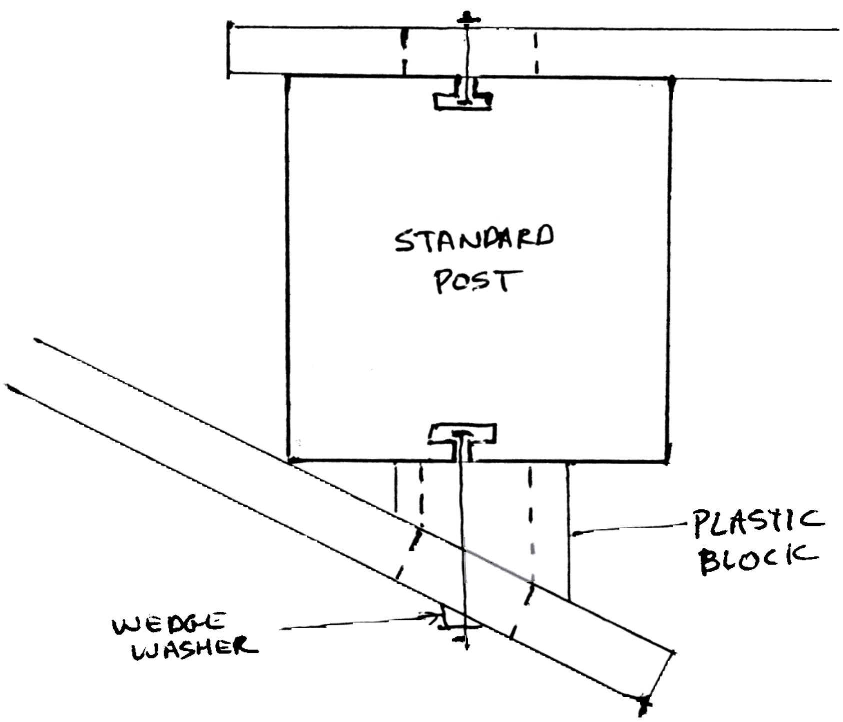
Fig   of highway side wall

Fig.   Detail of post tops set below   of

WK
6/99

HORIZONTAL ALIGNMENT CHANGE



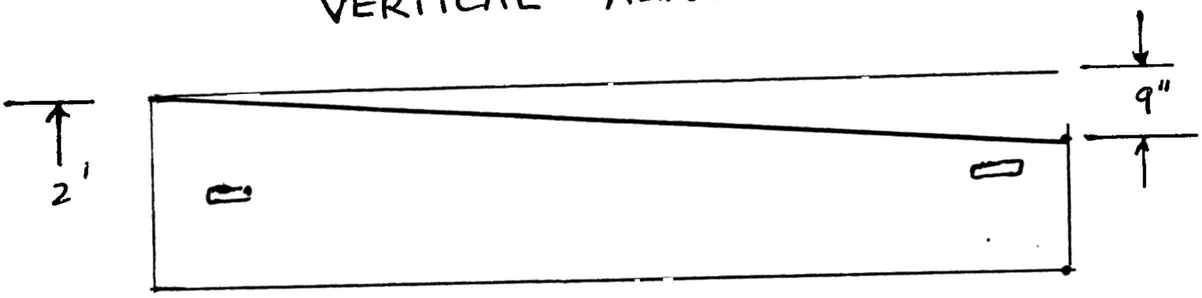


NTS

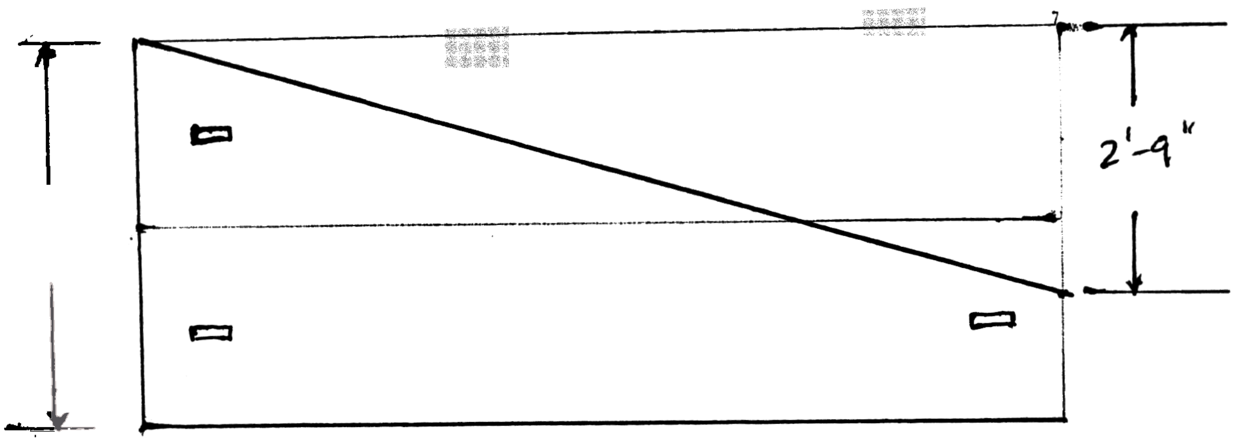
FIG. 48

WK 6/99

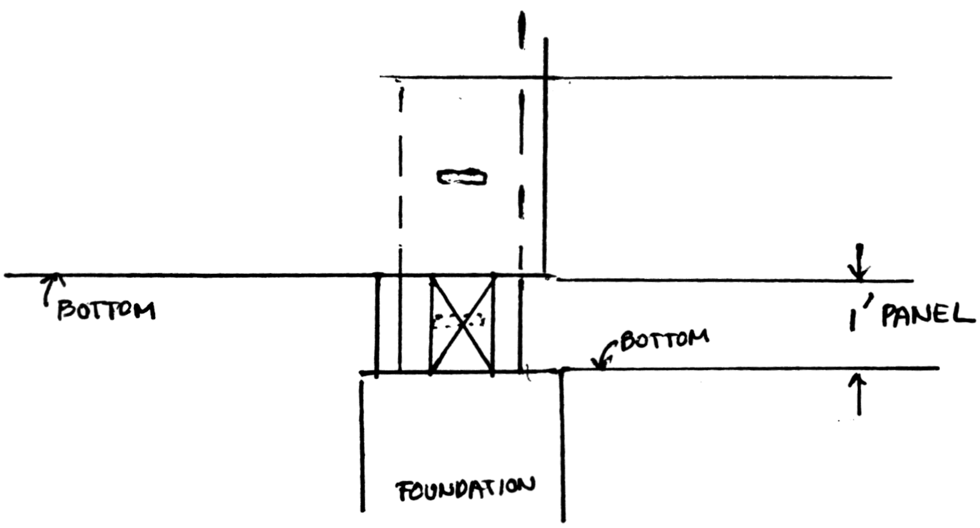
VERTICAL ALIGNMENT CHANGE



AT TOP



AT TOP



AT BOTTOM

NTS

FIG 49

WK
6/99

FIN ATTACHMENT COST FOR PROTOTYPE WALL

MATERIALS

FINS — 136 lin ft of metal fins @ $6.94/lin ft = $944

FIN ANCHORS — @ $227/1,000 × 400 = $

FIN BOLTS + WASHERS (SS) $10/100 × 400 = $

PRODUCTION.

FIN ANCHOR PLACEMENT DURING CASTING AND CLEAN/TAP ANCHORS AFTER CASTING LABOR @ $30/hr. CASTING YARD.

FIN PANEL AREA — 918 sq ft.

TIME NEEDED AT YARD TO PLACE ANCHORS AND CLEAN/TAP @ 140 sq ft/hr

$$\frac{918 \text{ sq ft of panel}}{140 \text{ sq ft of panel/hr}} = 6.56 \text{ hr} @ \$30/\text{hr} \quad = \$197$$

FIN ATTACHMENT AT CONSTRUCTION SITE - LABOR @ $60/hr. CONSTRUCTION SITE

60 LIN FT of FIN / 2 MAN CREW / hour

$$\frac{136 \text{ lin ft of FIN}}{60 \text{ lin ft/hr}} = 2.27 \text{ hr} @ \$120/\text{hr} = \$272$$

TOTAL: $1,544

PANEL AREA — $17 \times 18 \times 3 = 918 ft^2$

WALL AREA — $45 \times 18 = 810 ft^2$

FIN COST $$\frac{\$1{,}544}{810 \text{ sq ft of wall}} = \$1.91/ft^2 \text{ OF WALL} = \frac{\$1{,}544}{136 ft} = \$11.35/$$

FIG 50

WK
6/99

PANEL TO POST ATTACHMENT COST FOR PROTOTYPE WALL AT A CONSTRUCTION SITE.

PANEL ERECTION COST.

CREW — 2 LABORERS, 1 CRANE OPERATOR } @ $180/h

EQUIP — 20 TON CRANE } @ $30/h

CREW + EQU. COST. = $210/h.

4'×17 panel req. 4 T BOLTS. (68 sq ft of PANEL)
PANEL HOOK UP, LIFT, LADDER PLACEMENT, TBOLT ATTACHMENT
TOOK ON AVE 6 min. or 680 ft² of panel/crew hour.

$$\frac{918\ ft^2\ of\ panel}{680\ ft^2\ of\ panel/crew\ h} = 1.35\ h\ @\ \$210/h = \$284$$

$$\frac{\$284}{810\ sq\ ft\ of\ wall} = \$0.35/sq\ ft\ of\ wall$$ (PANEL ERECTION COST ONLY)

SYSTEM MATERIALS COST (ESTIMATE FOR LONG WALL - NEGLECT END EFFECTS)

HALFEN - HT 3100 - GAL CHAN: @ $84/20

6 channels @ $84/20' ______ $504

T BOLTS, NUTS, WASHERS. - GAL - M16 @ $6/T BOLT

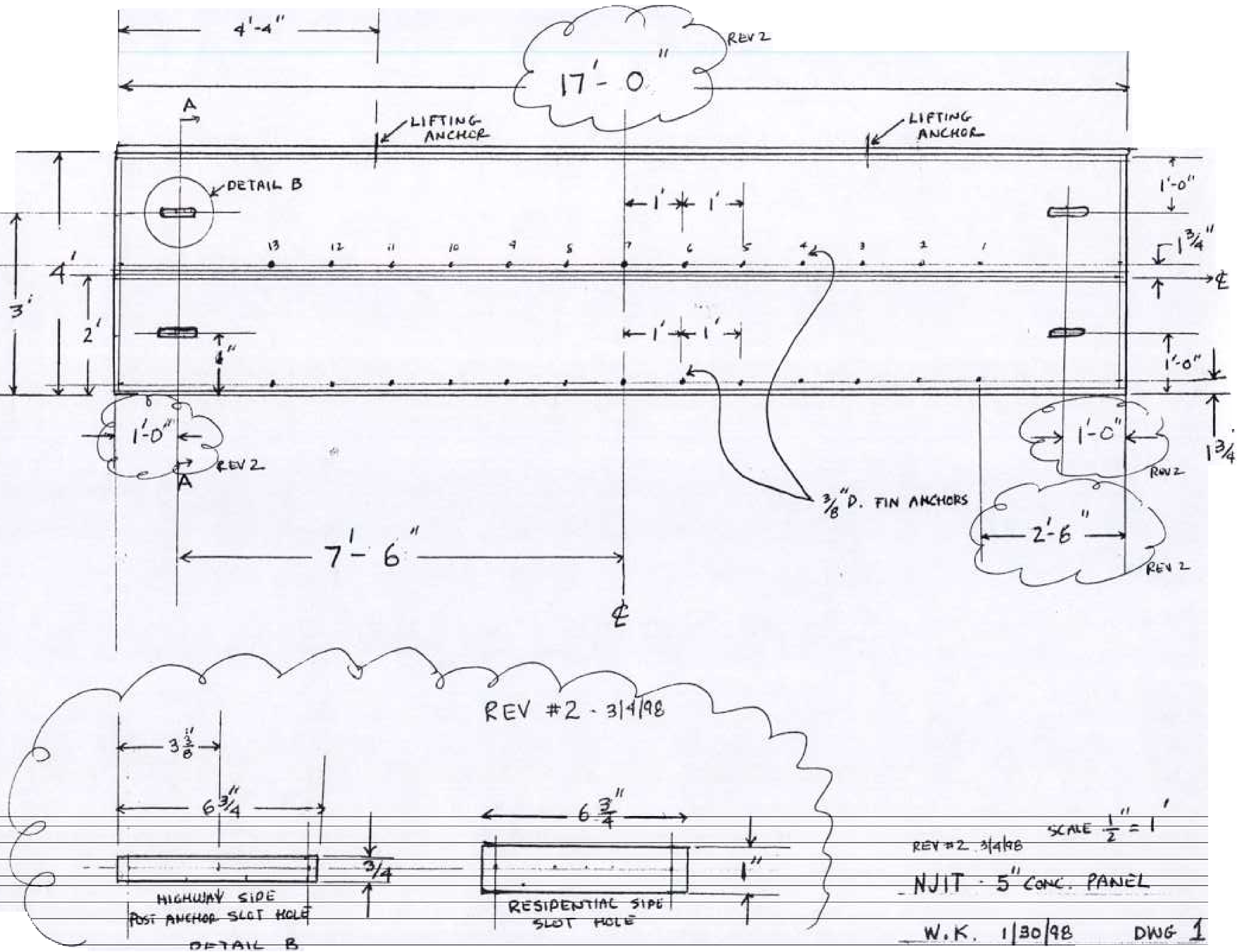
54 T BOLTS @ $6/T BOLT ______ $324

MATERIALS. ___ $828

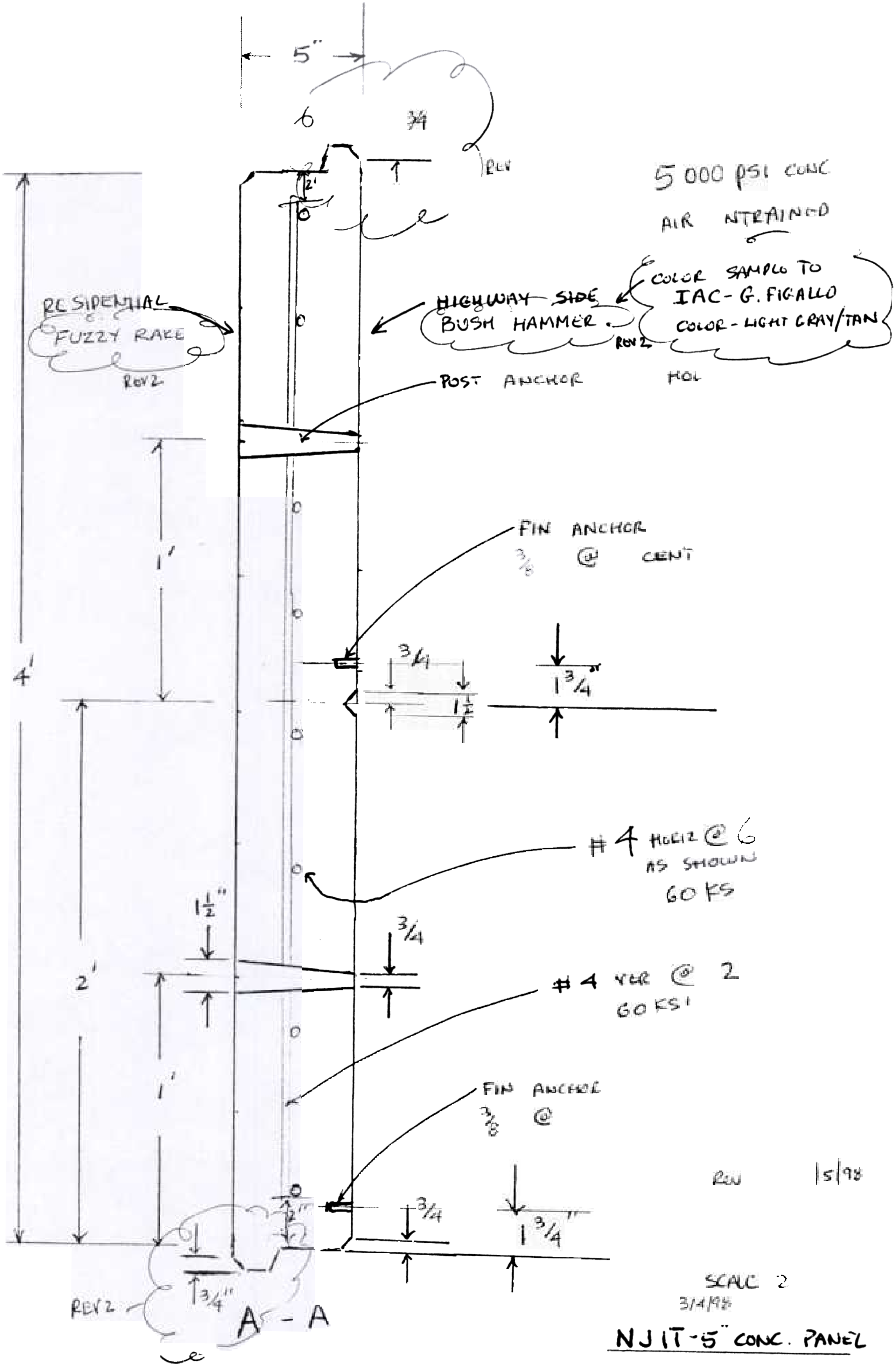
$$\frac{\$828}{810\ sq\ ft\ of\ wall} = \$1.02/sq\ ft\ of\ WALL.$$

FIG. 51

APPENDIX


4'-4"
17'-0"
REV 2
LIFTING ANCHOR
LIFTING ANCHOR
DETAIL B
A
A
1' 1'
1' 1'
13 12 11 10 9 8 7 6 5 4 3 2 1
1'-0"
1 3/4"
1'-0"
4'
3'
2'
6"
1'-0"
1'-0"
1 3/4
3/8"D. FIN ANCHORS
2'-6"
7'-6"
REV #2 - 3/4/98
3 3/8"
6 3/4"
3/4
6 3/4"
1"
HIGHWAY SIDE
POST ANCHOR SLOT HOLE
DETAIL B
RESIDENTIAL SIDE
SLOT HOLE
REV #2 3/4/98
SCALE 1/2" = 1'
NJIT - 5" CONC. PANEL
W.K. 1/30/98
DWG 1

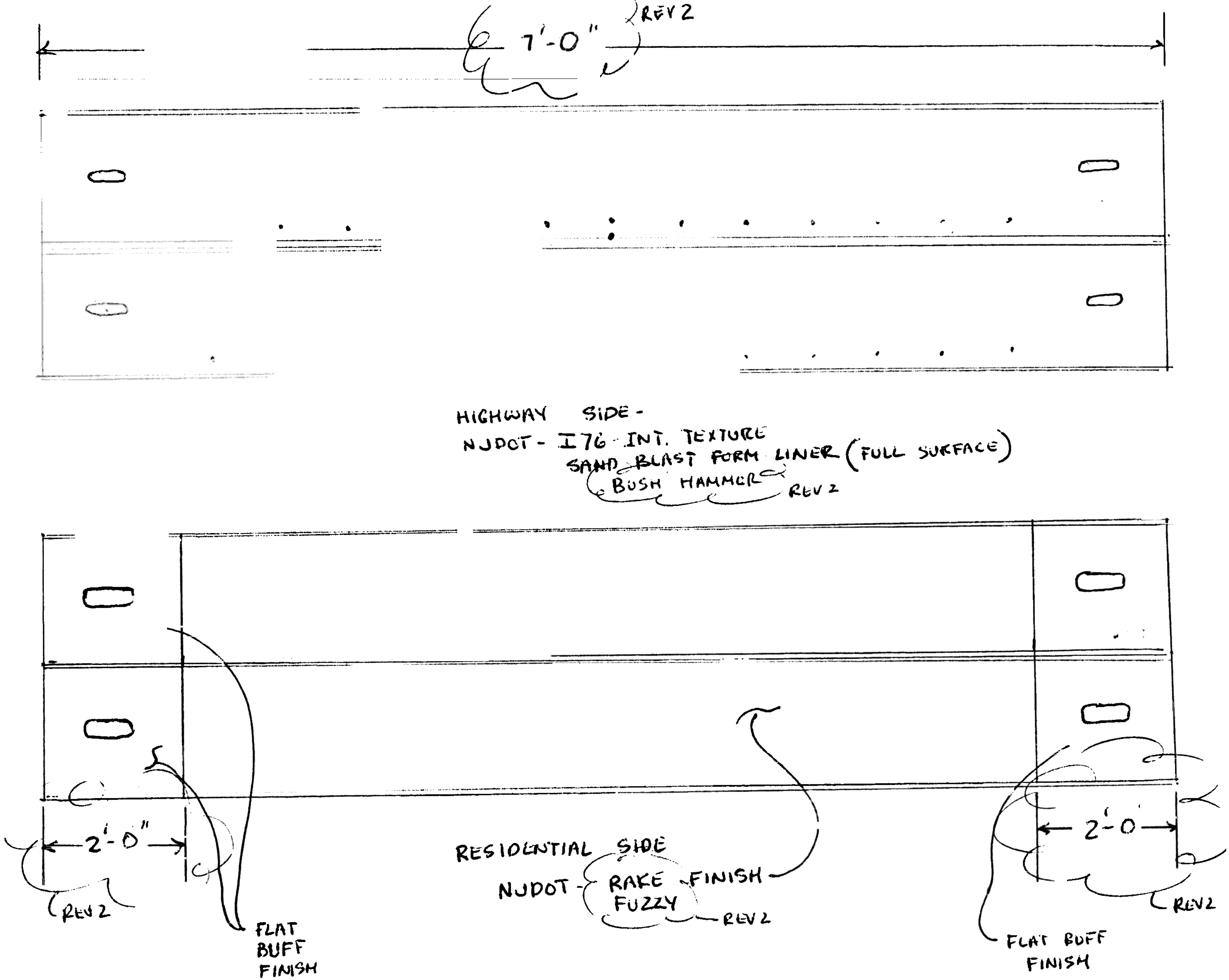
APP. I



SCALE 2
3/4/98

NJIT-5" CONC. PANEL

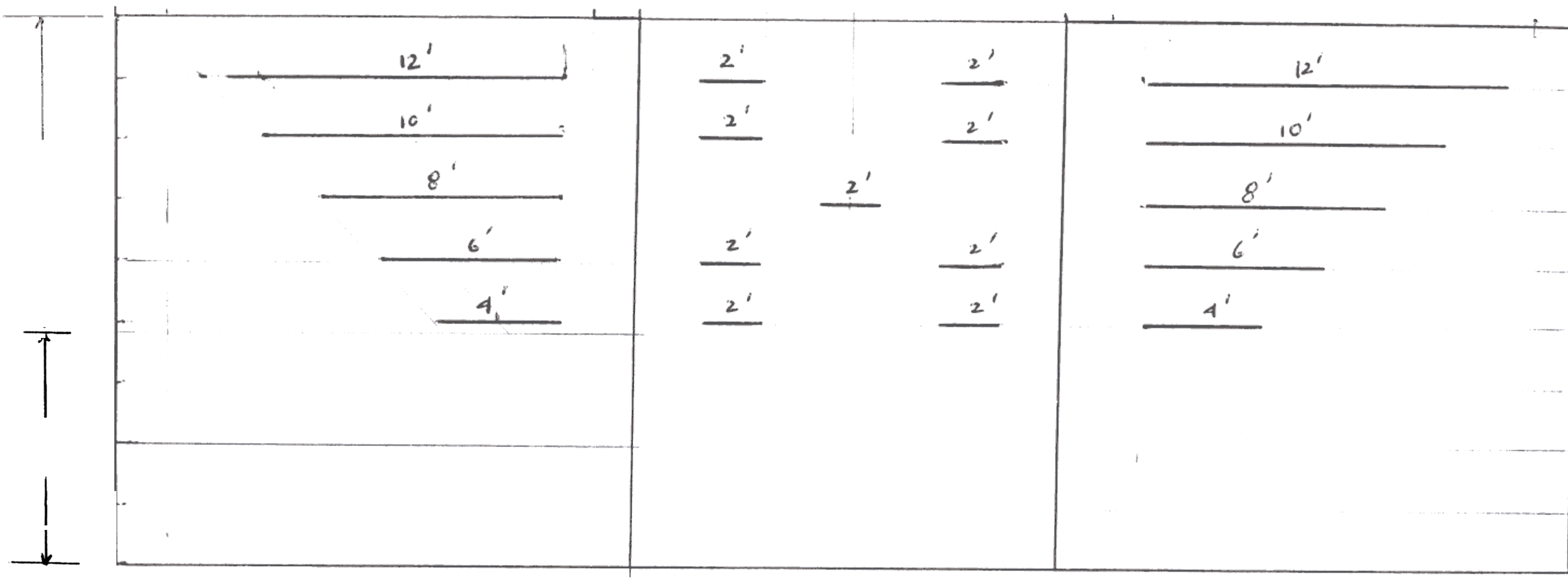
W.F 1/30/98 DWG 2
APP I



SURFACE FINISH

REV 2 - 3/4/98
NJIT - CONC. PANEL
W.K. 1/30/98 DWG 3

APP.I



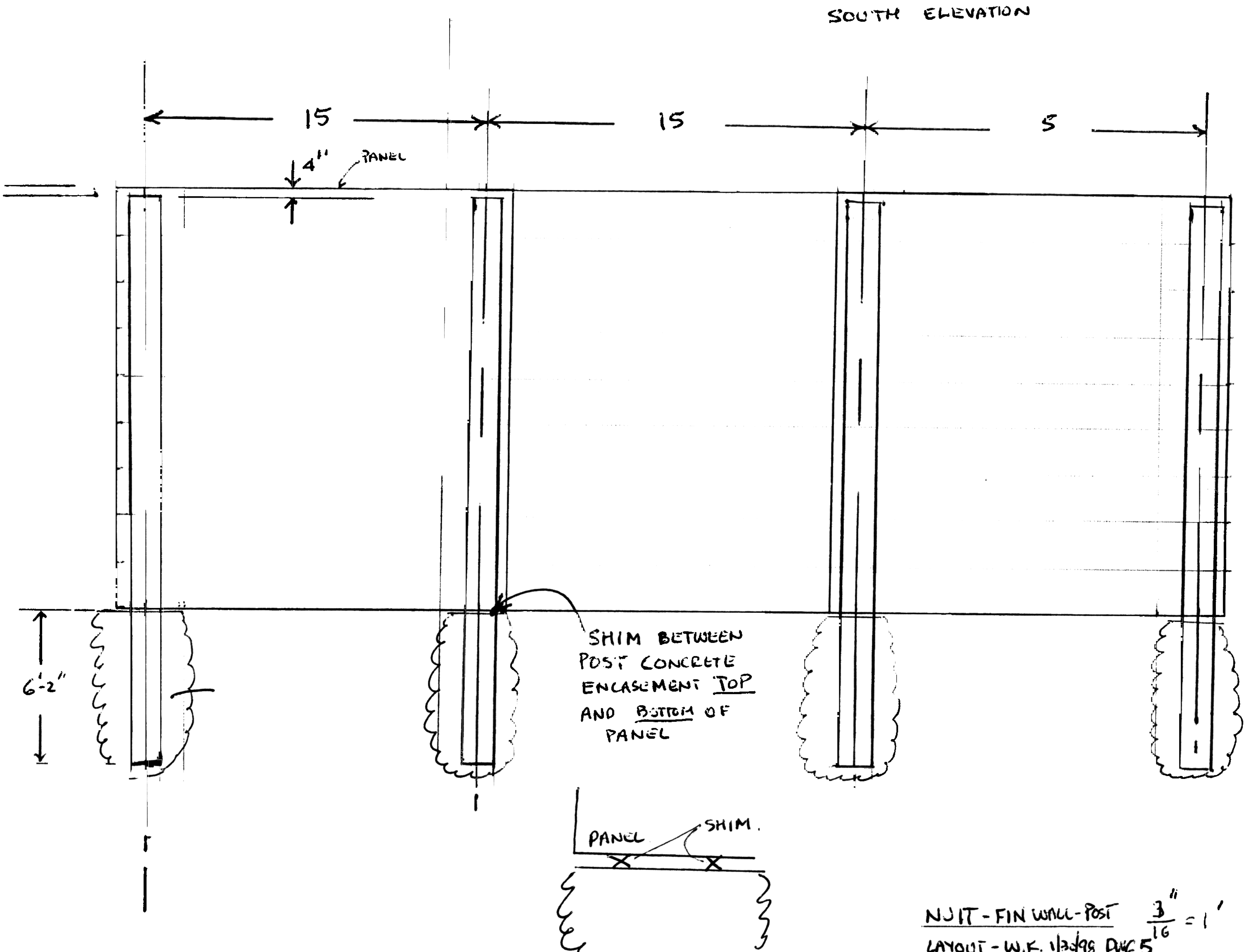
API I

W.K. 1/25/98

NJ11 FIN LAYOUT

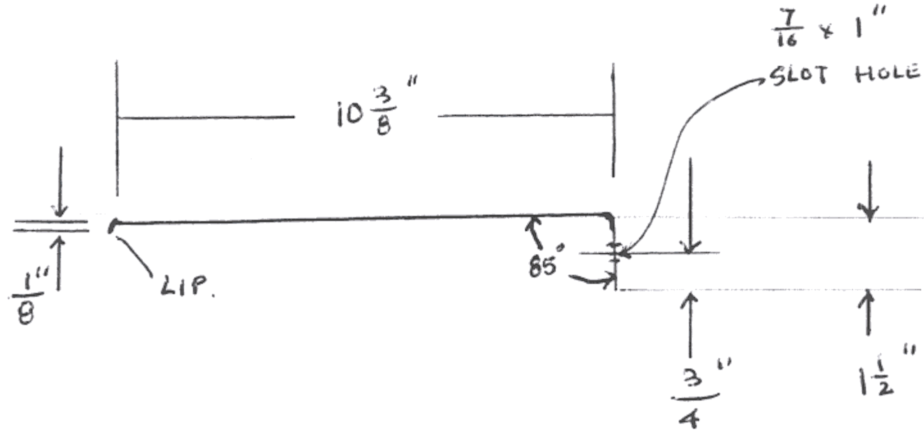
WK 1/30/98 DWG 4

3/16



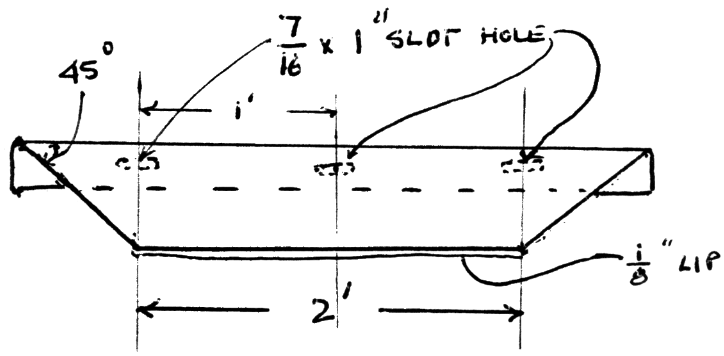
NJIT - FIN WALL - POST LAYOUT - W.K. 1/30/98 DWG 5 $\frac{3}{16}$" = 1'

APP I



14 GAUGE STEEL

POWDER COATED FINISH - CONCRETE TAN/GRAY



TWO FOOT LONG FIN

FOR DWG 4 FIN LAYOUT

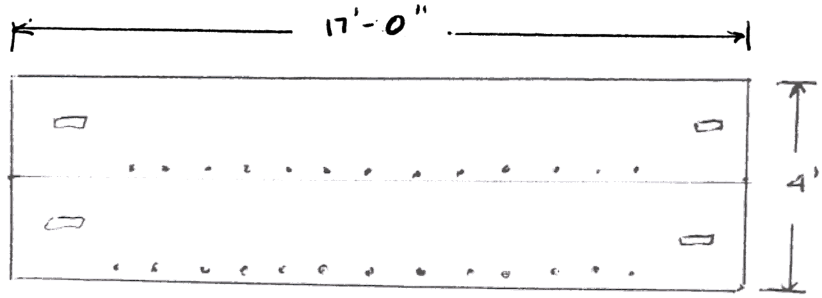
NEED	ORDER
2 x 12'	2 x 12'
2 x 10'	2 x 10'
2 x 8'	2 x 8'
2 x 6'	2 x 6'
2 x 4'	2 x 4'
9 x 2'	11 x 2'
98 LIN FT.	102 LIN FT.
38 ∠45 ENDS	42 ∠45 ENDS
136 LIN FT	144 LIN FT

NJIT - FIN DETAIL

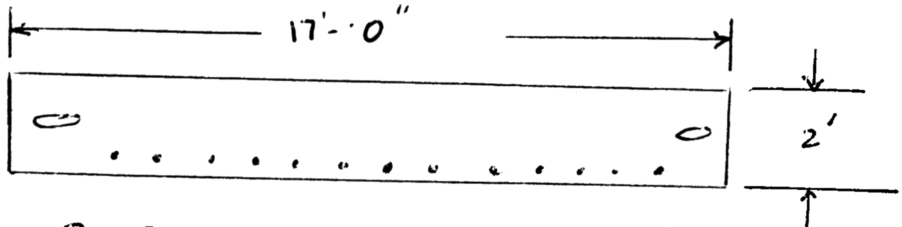
WK 1/30/98 DWG 6

APP I

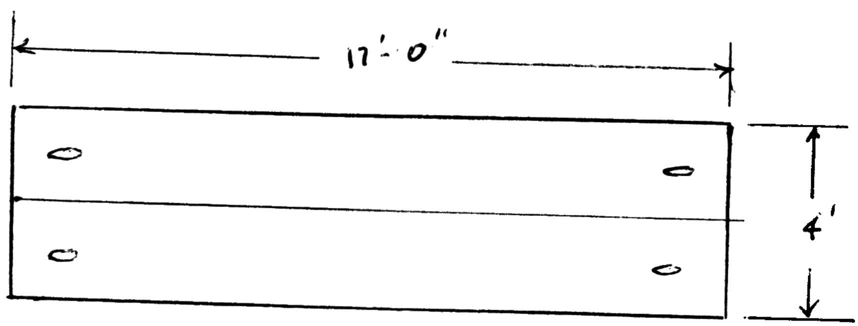
PANELS NEEDED FOR NJIT FIN WALL SHOWN ON DWG 4



NEED - 6 PANELS WITH FIN ANCHORS 2 ROWS



NEED 3 PANELS WITH FIN ANCHORS 1 ROW



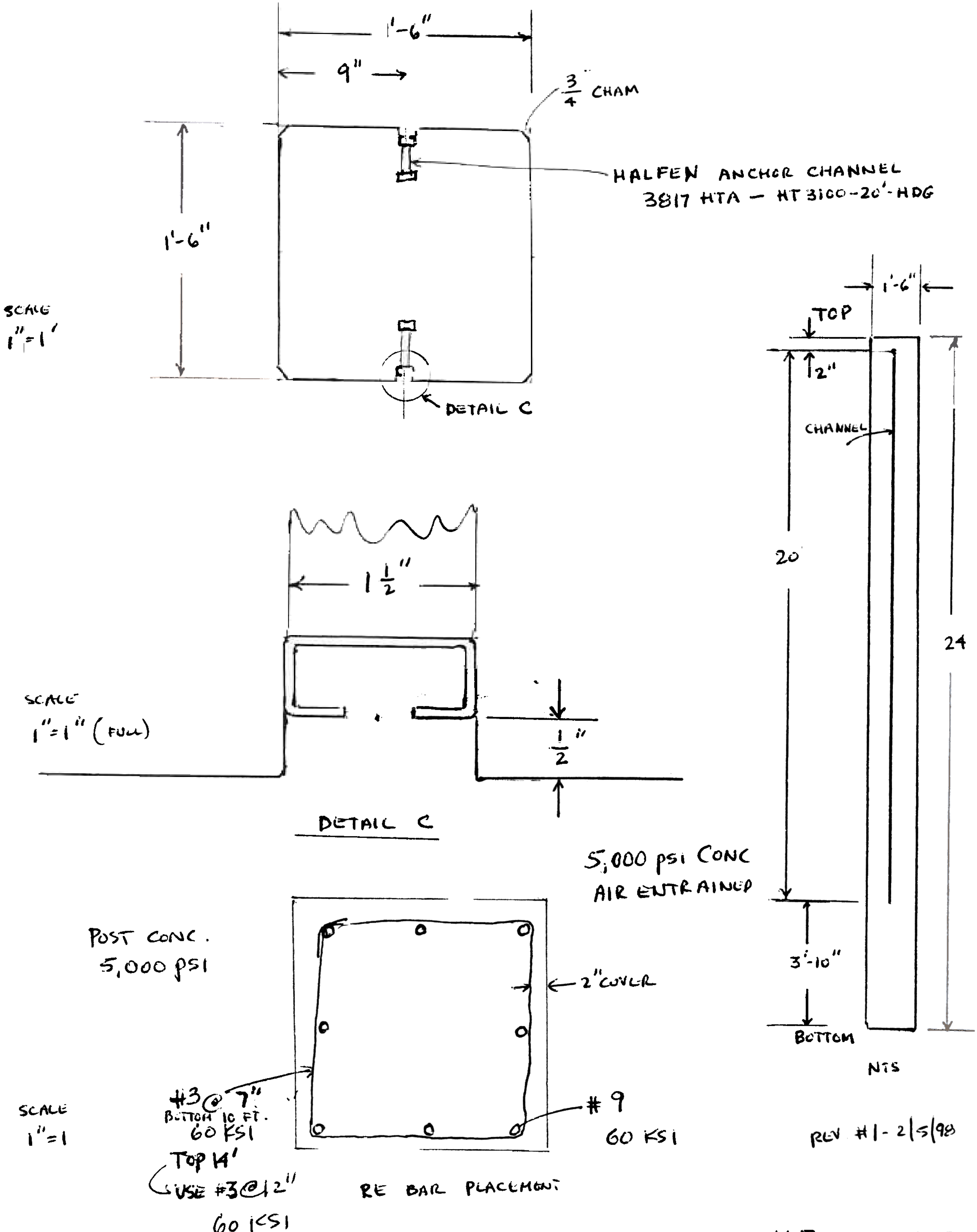
NEED 6 PANELS WITHOUT FIN ANCHORS

N.T.S.

NJIT 5" CONC. PANELS

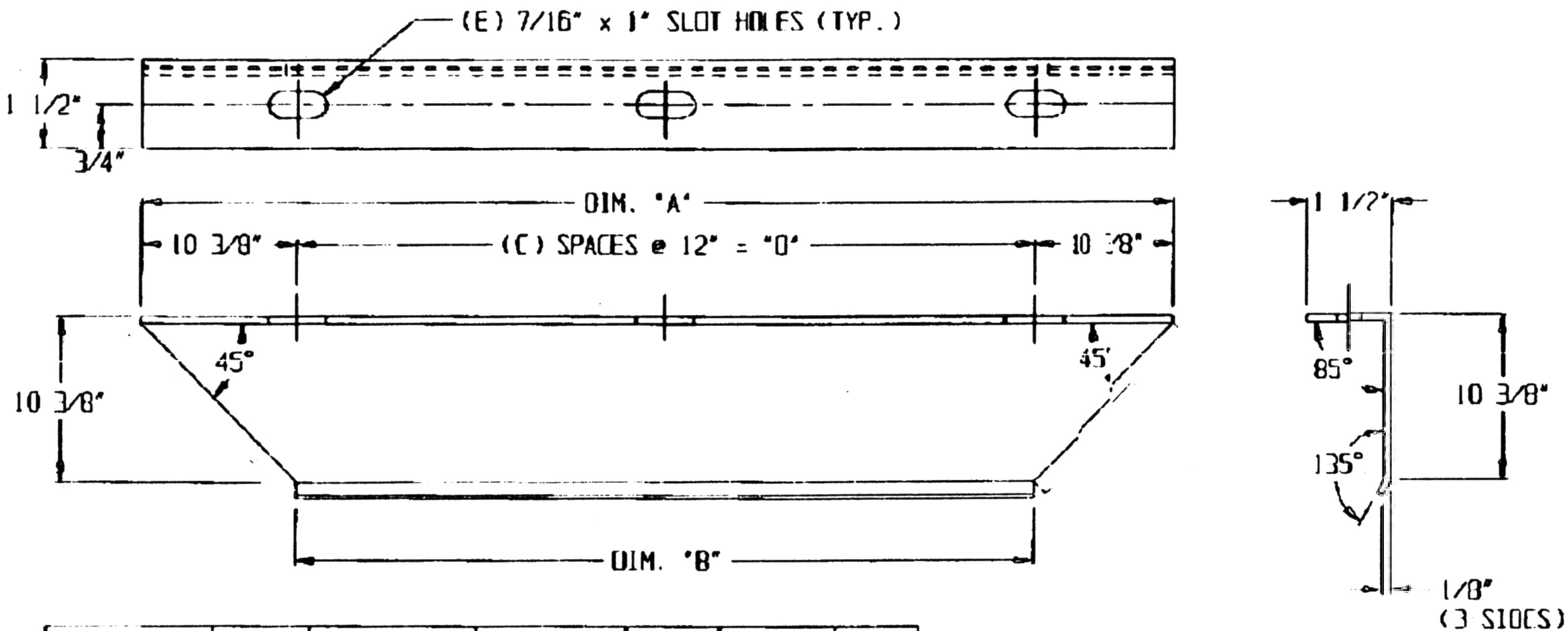
W.K. 1/30/98 DWG 7

APP I



NJIT – FIN WALL POST

W.K. 1/30/98 DWG 8



MARK No.	QTY.	DIM. 'A'	DIM. 'B'	'C'	'D'	'E'
A-1-1	2	164 3/4"	144"	12	144"	13
A-1-2	2	140 3/4"	120"	10	120"	11
A-1-3	2	116 3/4"	96"	8	96"	9
A-1-4	2	92 3/4"	72"	6	72"	7
A-1-5	2	68 3/4"	48"	4	48"	5
A-1-6	11	44 3/4"	24"	2	24"	3

MATERIAL: 14 GAUGE CRS

PAINT FINISH: POWDER COAT - MORTEN POLYESTER BEECHWOOD (20-8247) OR EQUAL

3/26/98.

OK to release
W. Kiwan
3/26/98

DESCRIPTION

NJIT FINS FOR CONCRETE SAFETY SYSTEMS

ISSUE	DATE	BY	DESCRIPTION OF ISSUE	OK
A	03/24/98	VK	FOR FABRICATION	WK

SCALE

INDUSTRIAL ACOUSTICS COMPANY, INC.
1160 COMMERCE AVENUE BRONX, N.Y. 10462

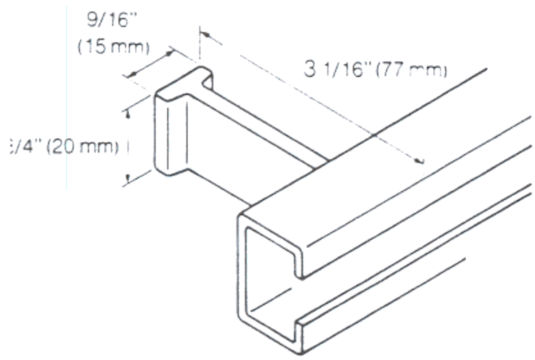
JOB # 33-0083

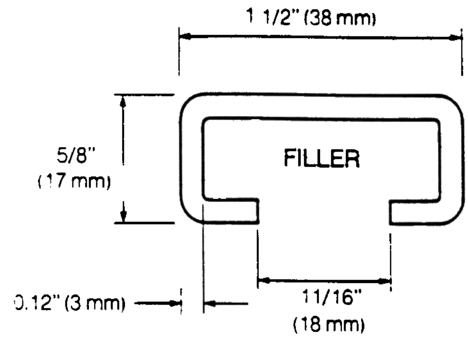
DWG. A-330083-1

FILE NO. IND 599

Loads given in this table apply only to bolt positions shown in the illustrations below. For other load configurations, consult Halfen.

3817 HTA
ANCHOR CHANNEL





FINISHES: HOT DIP GALVANIZED
STAINLESS STEEL AISI 304
AISI 316

LOAD DATA AND PART NUMBERS

Standard Short Pieces With 2 Anchors		Allowable Load			
Part Number	Channel Length (inches)	Pull Out (lbs) f	Shear (lbs) f	Pull Out (lbs) f	Shear (lbs) f
HT3506	6	1545	1930	1800	1930
HT3508	8	1545	1930	1700	1930
HT3110	10	1545	1930	1600	1930
HT3112	12	1375	1930	1500	1930

Standard Short Pieces With 3 Anchors			Allowable Load			
Part Number	Channel Length (inches)	Minimum Spacing Between Point Loads (inches)	Pull Out (lbs) F	Shear (lbs) F	Pull Out (lbs) F	Shear (lbs) F
HT3510	10	4	3090	3750	3600	3750
HT3512	12	5	3090	3750	3400	3750
HT3518	18	8	3090	3750	3200	3750
HT3124	24	10	2750	3750	3000	3750

Long Lengths Up To 20 Feet. Anchors at Either 5" Or 10"			Maximum Point Loads:		Uniformly Distributed Loads: Per Linear Foot	
Part Number	Anchor Spacing (inches)	Minimum Spacing Between Point Loads (inches)	Pull Out (lbs)	Shear (lbs)	Pull Out (lbs)	Shear (lbs)
USE → HT3100	10	10	1375	1930	1650	2300
HT3500	5	loads provided upon request				

BOLTS AND LOCKING PLATES

Standard grade HALFEN Tee-head bolt type **M12 (1/2")** is recommended for use with this channel. Other diameters are available to special order. The following locking plates are available for use with regular Hex head bolts and threaded rods —
1/4", 5/16", 3/8", 1/2".
If longitudinal loads are required, it is recommended that type **M16 (5/8")** high tensile Tee-head bolts are used. Allowable longitudinal load available (3:1 Safety Factor) is:
1700 lbs.

Please refer to pages T-13 & T-14 for full bolt details.

HALFEN TEE-HEAD BOLTS

General

Halfen Tee-head bolts are the economical alternative to a stud nut. They offer high security because they are manufactured in one piece and are quickly installed through any part of the channel opening. The line on the visible end of the bolt (Fig. 3) corresponds with the position of the head of the bolt in the channel. This allows an easy check to ensure that the head of the bolt is correctly locked behind the channel lips. This feature is impossible to achieve on a conventional locking plate or channel nut, and so it is always difficult to ensure that the nut is properly turned in the channel or has an adequate number of threads engaged with its bolt. For these reasons the Tee-head bolt is the preferred means of anchoring to a Halfen channel. The Tee-head bolts are available only with metric threads and are always supplied with a matching nut. Extra nuts are readily available if needed.

Fig. 1 Hammer Head Bolt

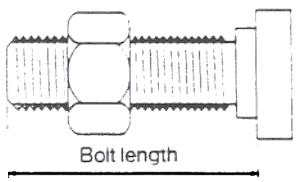


Fig. 2 Hook Head Bolt

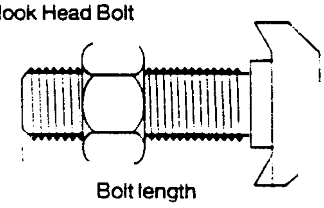
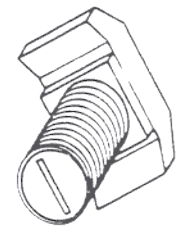


Fig. 3



TECHNICAL DATA

ACCESSORIES

Sizes, Finishes, and P/Ns

Two types of Tee-head bolts are supplied, the hammer head bolt (Fig. 1) for channels 2815 & 3817, and the hook head bolt (Fig. 2) for channels 4022, 4930, 5030, 5234, and 7248. Both types are available in HALFEN Standard and High Tensile grades. In all cases the length of the bolt is figured from the head, so projection length from the concrete face can be calculated by subtracting the thickness of the channel lips.

Electroplated and stainless steel finishes are readily available. Galvanized finishes are provided to order. For ordering, please use the base part number given in the following tables. Add a 1, 2, 3, or 4 to the end of the base part number depending on the finish required. Other bolt sizes can be supplied. Please consult HALFEN for details.

Electroplated to ASTM B-633 —	Add '1'	Example: BD2311
Hot dip galvanized to ASTM A-153	Add '2'	Example: BD2312
Stainless steel to AISI 304 —	Add '3'	Example: HN1213
Stainless steel to AISI 316 —	Add '4'	Example: HN1214

Standard Grade Tee-Head Bolts

		Preferred Bolt Length & Base P/N								(Nut is supplied with bolt)		Extra Nuts	Special Bolt Sizes	
Channel Ref.	Thread Size	⅝" 15 mm	¾" 20 mm	1" 25 mm	1¼" 30 mm	1½" 40 mm	2" 50 mm	2¼" 55 mm	2¾" 70 mm	3" 75 mm	4" 100 mm	Base Part No. Each	Bolt Diameters to Special Order	Bolt Lengths to Special Order
2815HTA									BL231		BP231	HN101	M6 & ~~M8~~	up to 6"
3817HTA	M12			BC341	BD341	BF341	BH341		BL341	BM341	BP341	HN121	M10 & M16	up to 7"
4022HTA	M12		BB441		BD441	BF441	BH441		BL441		BP441	HN121	M10	up to 8"
	M16				BD451	BF451	BH451		BL451	BM451	BP451	HN161		
4930HTA	M16				BD551	BF551	BH551		BL551		BP551	HN161	M10 & M12	up to 12"
5030HTA 5234HTA	M20							BI561		BM561	BP561	HN201		
7248HTA	M24						BH771			BM771	BP771	HN241	M20,M27 & M30	up to 10"

All sizes with Base P/N available electroplated | Available electroplated & S/S AISI 304 & 316 | Available electroplated & S/S AISI 316

Pullout & Shear Loads

USE

	Allowable Loads in Lbs. on Standard Grade Bolts in Pullout & Shear								
Bolt Diameter	M6	M8	M10	M12	M16	M20	M24	M27	M30
		890	1405	2045	3815	5950			
Recommended Torque (ft.-lbs.)	2	6	11	19	44	88	147	220	295

High Tensile Grade Tee-Head Bolts

HALFEN high tensile grade bolts have greater strength than the standard grade range of bolts. They may be used for the channel sizes indicated below. but care should be taken to ensure the load applied does not exceed the capacity of the channel.

Slip Loads

It is recommended that if high slip loads are required (the load being applied longitudinal to the channel) that HALFEN channel 4122 HZA is used with toothed HALFEN bolts. Alternatively high tensile Tee-head bolts can be used in any of the HALFEN channels and high torques applied to acheive an increased slip load. Details of loads and torques are given below.

Channel Ref.	Thread Size	High Tensile Bolt Length & Base P/N (Nut is supplied with bolt) 1 3/8" (35 mm)	1 1/2" (40 mm)	1 3/4" (45 mm)	2" (50 mm)	2 5/16" (60 mm)	2 3/4" (70 mm)	3" (75 mm)	Extra Nuts Base P/N Ea.	Required Torque for Slip Loads ft.-lbs.	Allowable Slip Load lbs.	Allowable Pullout & Shear Load Lbs.
2815HTA	M10		BF232						HB102	35	650	3340
3817HTA	M16					BJ352	BL352		HB162	140	1700	9260
4022HTA	M16		BF452			BJ452			HB162	140	1700	9260
4930HTA 5030HTA	M16					BJ552			HB162	140	1700	9260
5234HTA	M20			BG562		BJ562		BM562	HB202	285	2300	14450
7248HTA	M24							BM772	HB242	[illegible]	[illegible]	20820
4122HZA	M12*	BE942			BH942				HB122	55	1200	4886
4122HZA	M16*				BH952				HB162	55	1200	9260

*Available in Standard Grade AISI 304 & 316 — Preferred Finish Galvanized — Preferred Finish Electroplated

Before applying very high torques, ensure the face of the channel is level with the surface of the concrete, and that a substantial plate washer is used under the nut to resist crushing the component. See page T-2.

Using Tee-head Bolts

The stud of the Tee-head bolts and their matching nuts have metric dimensions. The table gives recommended clearance hole sizes in components to be anchored, and appropriate wrench sizes for tightening nuts. Although it is good practice to use a torque wrench for tightening nuts it is not essential, unless the load is being applied longitudinally to the channel. Tightening with a wrench in a 'normal' manner is usually all that is required. If a metric wrench is not available an adjustable wrench may be used for the smaller bolts. Metric wrenches are available from HALFEN on request.

Bolt Thread Ref.		M6	M8	M10	M12	M16	M20	M24	M27	M30
Bolt Diameter in Millimeters		6	8	10	12	16	20	24	27	30
Equivalent Diameter in inches		0.236	0.315	0.394	0.472	0.630	0.787	0.945	1.063	1.181
Recommended thru Hole Size in Component to be Anchored	min. (ins.)	1/4	11/32	13/32	1/2	21/32	13/16	1	1 3/32	1 1/4
	max (ins.)	9/32	3/8	7/16	9/16	3/4	15/16	1 1/8	1 3/16	1 7/16
Metric Wrench Size (mm)		10	13	17	19	24	30	36	41	46

HALFEN WASHERS

General

HALFEN washers are available in metric sizes to suit the range of Tee-head bolts. Washers are supplied to order.

USE →

Sizes, Finishes, and P/Ns

Electroplated and stainless steel finishes are readily available. Galvanized finishes are provided to order. For ordering, please use the base number given below. Add a 1,2,3, or 4 to the end of the base part number depending on the finish required as described in the Tee-head bolt section (Pg. T-13).

For Bolt Size	Washer Base P/N	Dimensions (ins.) D	d	T
M6	HW061	7/8	1/4	5/64
M8	HW081		11/32	5/64
M10	HW101	1 3/16	13/32	3/32
M12	HW121	1 3/4	5/8	5/32
M16	HW161	2	11/16	1/8
M20	HW201	2 5/8	13/16	3/16
M24	HW241	1 3/4	1	5/32
M27	HW271	2	1 3/32	5/32
M30	HW301	2 3/16	1 7/32	5/32

All sizes with Base P/N available electroplated — Available electroplated & S/S AISI 304 & 316 — Available electroplated & S/S AISI 316