POLICY, PLANNING, & INTERMODAL DEVELOPMENT DIVISION

Research & Development Section

Prepared by:

Jonathan Razinger
Research Engineer

Attendee(s):

Jonathan Razinger, Research Engineer
Ryan Barnes, VHB Engineer
Howard Garrow, Driller
Mark Meunier, Maintenance Supervisor

June 16, 2017 | **FIELD REPORT** | **U2017-02**

Utilization of Ground Penetrating Radar (GPR) to Detect Shear Bolts in Bridges -- Colchester Bridges 77 & 76 – US I-89

EA: Experimental Features - SPR 352

Work Plan: WP 2015 R-4

Background:

The Research Section was approached by Callie Ewald, the Geotechnical Engineering Manager, to determine if Ground Penetrating Radar (GPR) can detect the presence of shear bolts on two bridge decks in the Colchester Vermont area. Shear studs are placed on the top flanges of steel girders to increase stiffness and strength by producing a composite action between the concrete bridge slab and the steel girders. The construction plans, shown in *Appendix I*, option the use of Channel, Stud or Spiral shear studs on both southbound and northbound, 76 and 77 bridges on I-89. This report describes the two site visits on October 31, 2016 and November 16, 2016.

Future construction work on the bridges has been proposed. The question arose whether shear studs were installed to the steel girders during original construction. As mentioned above, the construction plans option the use of certain shear studs, but there is no verification of their installation. The Research Section has been currently working on an initiative to implement the use of GPR throughout the Agency. Callie Ewald was aware or this initiative and saw this as an opportunity to determine if GPR could be used to detect and locate shear studs effectively to cut down the number of cores that must be drilled to visually confirm the presence of shear studs. At this point, the Agency is not looking to phase out drilling cores to visually confirm the presence of shear studs, but to determine if the work can be accomplished more efficiently.

The locations of specific bridge elements many vary from the initial construction plans or as-built plans, which in some cases may not even exist. Currently, the bridge engineer looks at the construction plans and selects test sites throughout the bridge to drill cores. The test sites are positioned above the steel girder at specific locations throughout the span of the bridge. Each test site is comprised of a cluster of approximately five cores geometrically spaced above the presumed location of the steel girder and shear studs. The geometric pattern used will vary depending on the preferences of the bridge engineer. The bridge engineer for this project, Ryan Barnes from Vanasse Hangen Brustlin (VHB), preferred a zig-zag pattern. This can be seen in Figure (3) under Area 1 with the exclusion of L6. The cluster of five cores accounts for the possible errors of missing the steel girder or shear studs due to human error or inconsistencies in the construction plans. The goal is to use GPR to eliminate those errors and more effectively determine the true locations of these particular bridge deck elements. This would decrease the number of cores that need to be drilled, decrease the job and lane closure times and get traffic to normal rates and speeds at a faster rate.

Research Section's GPR Unit Specifications:

- Model: GSSI StructureScan Standard
- Controller: SIR-3000
- Software: RADAN 7
- Antenna: 1600MHz (High Frequency, Scan depth up to 18")
- Model 615 handcart with encoder

Date: Monday, October 31, 2016

Time: 8:00 AM to 4:00 PM

Weather: 40˚F, Cloudy

A field study to determine the effectiveness of GPR to locate shear studs in concrete bridge decks was conducted on southbound bridges 76 and 77, near the town of Colchester on US I-89. A field visit was conducted on the bridge 77 (southbound) near mile marker 96.566. The location of bridge 77 can be seen in Figures (1 & 2). VHB was interested in determining the presence of shear studs because their presence dictates the type, method and cost of bridge deck reclamation needed for a future construction project. Observations, photos, and notes were taken during the site visit. The objective of this study was to determine if GPR could be used as a supplemental technology to effectively determine the presence and location of shear studs on a bridge deck, decreasing the number of cores that need to be drilled to visually confirm the presence of shear studs.

Figure 1: Topographic View of Bridge 77 on I-89 at MM 96.566 (Google Maps)

Figure 2: Street View of Bridge 77 on I-89 at MM 96.566 (Google Maps)

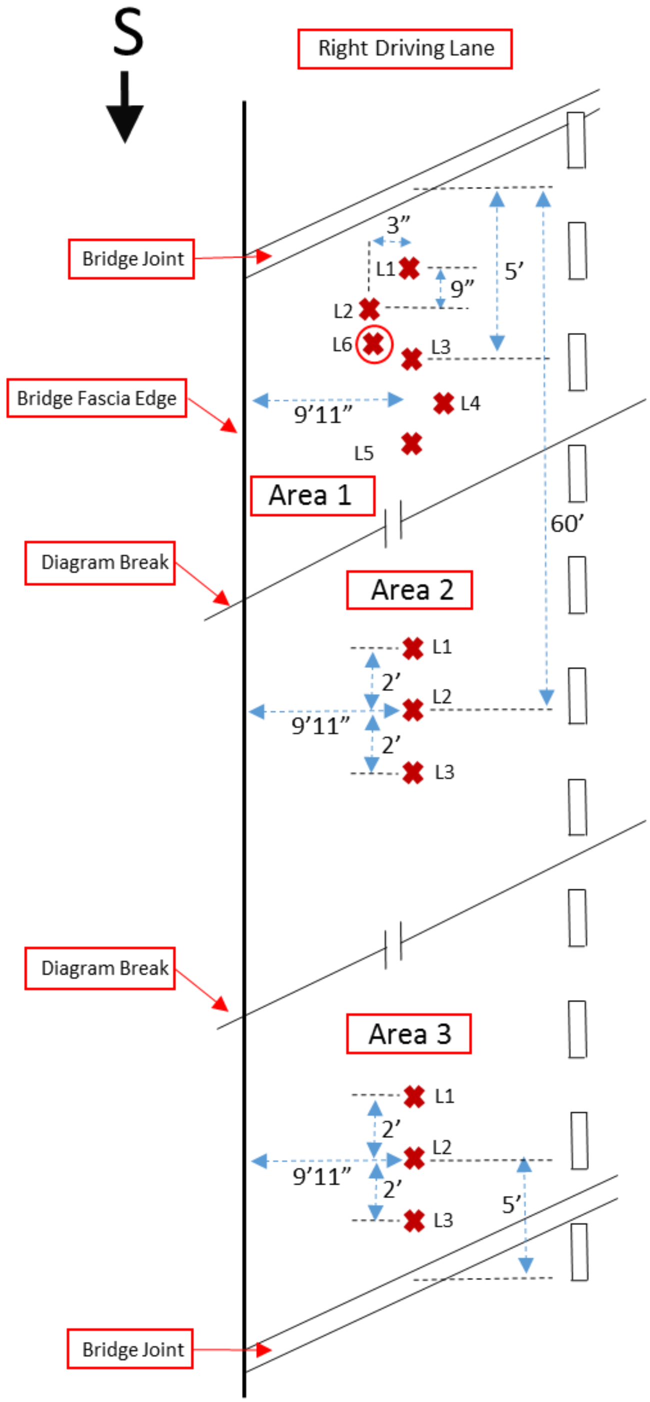


Figure 3: I-89 Bridge 77 Core Drilling Diagram Near Colchester

Field Notes & Observations:

In total ten cores were drilled on bridge 77. Three test areas were designated throughout the span of bridge 77. The test areas were chosen by VHB engineers. Initially to increase the drilling area and probability to locate the shear studs and beam girder, VHB engineers laid out the drilling locations in a zig-zag pattern and suggested using a 4in drilling bit. This can be seen in Area 1 of Figure (3) excluding L6. Due to measurement errors in locating the steel girder the initial zig-zag layout was abandoned. Howard Garrow, the driller, and myself suggested applying a more traditional straight-line layout and increasing the core diameter to 6in. This layout can be seen in Areas 2 & 3 of Figure (3). The more simplistic layout is more efficient, due to the increased drilling area, and should reduce the error of missing the steel girder. The cores in Area 1 were drilled in the following order; L3 was the 1st core drilled, L4 was the 2nd, L5 was the 3rd and L6 was the 4th. The initial zig-zag coring layout was abandoned after the 2nd core drilled missed the steel girder.

Before the cores were drilled, the drilling layout was marked out and the GPR scans were conducted. Both the initial zig-zag layout and the handheld GPR unit can be seen in Figure (4), while a close-up of the Area 1 drilling layout is shown in Figure (5).

Core Sample and GPR Image Analysis

The GPR scan at Area 1 on bridge 77, depicted in Figure (6) [file 135], ran perpendicular to the steel bridge girders and ran a length of 20” (.5m) on either side of the girder, a total of 60” (1.4m). The scan went from the white shoulder line and past the drilling layout, seen in Figure (4). The scan clearly shows the 1st mesh at a constant depth of approximately 2.5 – 3” below the asphalt surface and a rebar spacing of about 12”. The GPR scan shown in Figure (7), was taken running parallel to the steel bridge girders along the drilling layout. The scan clearly shows rebar from the 1st mesh at a constant depth of approximately 2 – 2.5” below the asphalt surface and at a spacing of about 6”. Both scans faintly show a similar hyperbola pattern at a depth of 8 – 10”, which might correspond to the 2nd rebar mesh. Rebar depth calculations may differ due to the algorithms and the accuracy of the input data used in the GPR scan software. If done correctly the depth calculation error should be minimal. The core samples from Area 1, best seen in Figure (8), verify that the 2nd rebar mesh was at a depth of approximately 7.5 – 8” below the asphalt surface.

Bridge 77 Area 1 cores can be seen in Figures (8 – 12). The core from L3 was 4” in diameter and approximately 10” in length. The 1st and 2nd rebar meshes could clearly be seen. Other metal fragments were found in the bottom inch of the core. Initially we thought that this might be evidence of shear studs, but upon further inspection it was clear that the metal fragment could not correspond to a cross section of a shear stud. This was concluded when a similar fragment was found within the L6 core and after all core measurements were recorded the core was destroyed, revealing that the metal fragments correspond to mesh seats. The mesh seats are comprised of small diameter stainless steel rods that are used as spacers to ensure that the 1st rebar mesh is placed at the correct concrete slab depth. The mesh seats were tack welded to vertical rebar elements to the steel girder at certain intervals along the girder. This can be seen in Figures (11 & 12). The L3 core sample can be seen in Figure (9). Figure (8) shows the L4 core sample that went completely through the concrete bridge deck and missed the steel girder. The core clearly shows the two rebar meshes and it was clear that the initial staggering method was ineffective.

Figure (13) [File 137], corresponds to the GPR scan at Area 2 on bridge 77. The scan section was approximately 60” (1.6m) in length, running perpendicular to the steel bridge girders, from the white shoulder line to the middle of the travel lane, past the drilling layout. The GPR scans clearly show the 1st rebar mesh, at a depth of 2 - 3”, and what may be the faint definition of the 2nd mesh, at a depth of 5 – 6”. At approximately 40 – 50” (1 – 1.3m) into the scan something can be seen at a depth of about 8.3”. This was approximately at the location of the steel girder and where the Area 2, L2 core was drilled. Initially I thought that this might be evidence of a shear stud but, it could also be reflections from the steel girder along with reflections from the mesh seats. The depth and the prolonged curvature of the anomalies on the scan image help validate this assumption.

Bridge 77 Area 2 cores can be seen in Figures (14 – 20). All three cores at Area 2 were drilled using a 6” drill bit. The core at L2 was the first one that was drilled at approximately 12pm. The core was approximately 9” in depth with the 1st rebar mesh at 2.5” and the 2nd rebar mesh at 7”. The L2 core, seen in Figure (18), shows no evidence of shear studs. The core at L3 was drilled next. The 1st rebar mesh on the L3 core was at 2” and the 2nd rebar mesh at 7”. The L3 core, seen in Figure (19), shows no evidence of shear studs. The core at L1 was the last to be drilled in Area 2. The 1st rebar mesh at 2.5” and the 2nd rebar mesh at 6”. The L1 core, seen in Figure (17), again shows no evidence of shear studs.

Figures (21 & 22) [Files 138 & 139], correspond to GPR scans at Area 3 on bridge 77. Looking at the GPR scan from Figure (21) the 1st rebar meshes is clearly defined and the scan shows faint signs of the 2nd rebar mesh. The scan was taken from the white shoulder line to the middle of the travel lane, running perpendicular to the steel girder. At approximately 40” into the GPR scan some anomalies can be seen at a depth of about 8”. Because a shear stud has not been found on the bridge, the anomaly is most likely backscatter or a reflection from the steel girder as mentioned in Area 2. The scan depicted in Figure (22) ran parallel to the steel girder along the drilling layout, Figure (23). The 1st rebar mesh can be clearly seen at a depth of about 1” and a spacing of 6”. It is more difficult to see the 2nd rebar mesh because of the amount of backscatter and decrease of reflection energy at a depth of approximately 7”.

We were unable to stay out in the field to finish drilling the final 3 cores at Area 3. Drilling commenced again the following day (Tuesday, November 1, 2016) at Area 3 on bridge 77. I was not present when the 3 cores were drilled in Area 3. I arrived on the job site at 1pm and the drilling crew had moved from bridge 77 to bridge 76. Finishing up on bridge 77 took longer than expected due to the fact that the concrete filling material was taking longer than usual to cure. Later discussions with Ryan Barnes revealed that no shear studs were found when the cores at Area 3 were inspected. From the 10 cores on bridge 77 it was evident that shear studs are not present.

On bridge 76 the drilling crew was having difficulties drilling the cores at Area 1. The L1 core showed no evidence of shear studs. The drilling layout on bridge 76 can be seen in Figure (26). The drilling crew broke the threshold rod on the drilling rig while drilling out the L2 core, seen in Figure (15). The drilling bit became lodged within the bridge deck and could not be removed. The drilling crew cut the bit with a torch, leaving a part of the bit within the concrete bridge deck. During this time, Marcy Montague came out to the job site with a handful of other agency engineers to witness the GPR equipment working out in the field. I was able to give Marcy and the engineers a quick Demo on GPR technology and answered any questions that they had. Unfortunately, I was unable to verify what was depicted in the scans I showed those engineers to the physical evidence presented by the cores due to the drilling rig breaking.

Photos:

Figure 4: Area 1 Initial Drilling Layout and Handheld GSSI GPR Unit.

Figure 5: Close-up of Area 1 Initial Drilling Layout.

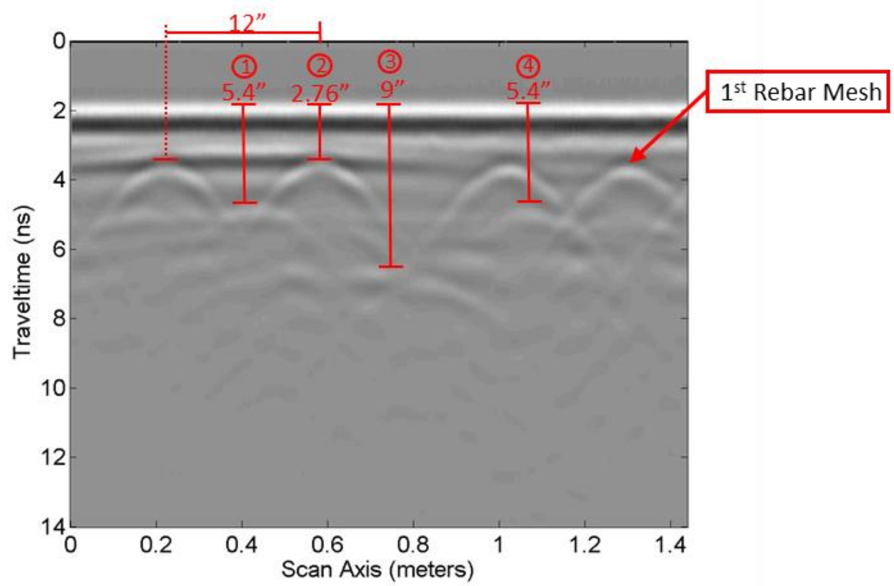


Figure 6: GPR Image (File 135), corresponds to a GPR scan on Area 1 on Bridge 77. Perpendicular to steel bridge deck girder.

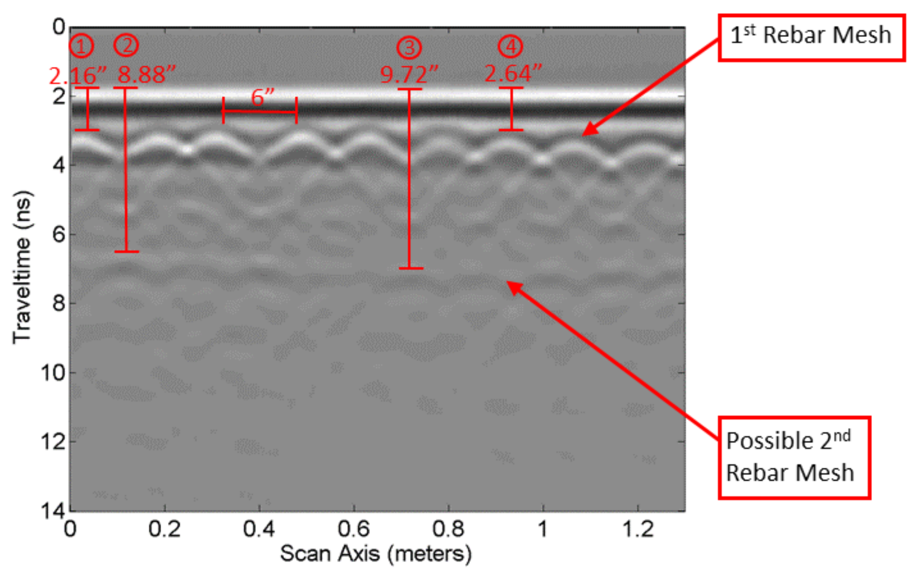


Figure 7: GPR Image (File 134), corresponds to a GPR scan on Area 1 on Bridge 77. Parallel to steel bridge deck girder.

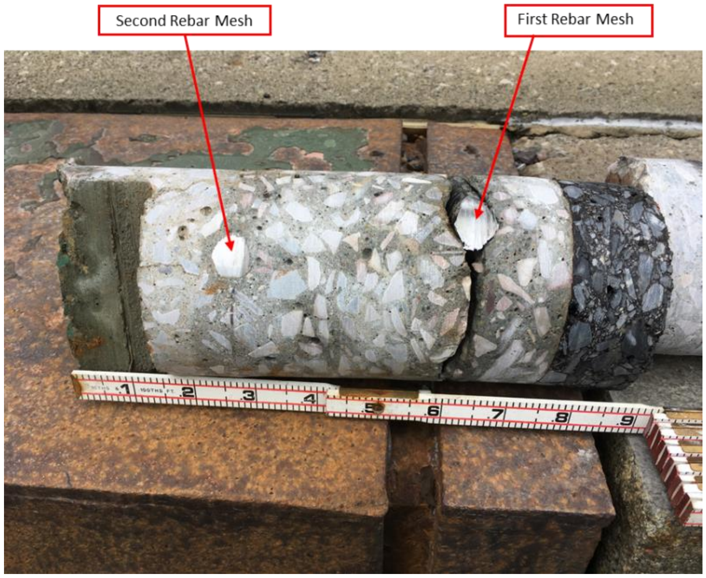


Figure 8: Area 1, L4 4in Core That Missed the Steel Girder. First and Second Rebar Meshes Can Be Clearly Seen. (Ruler in tenths of feet)

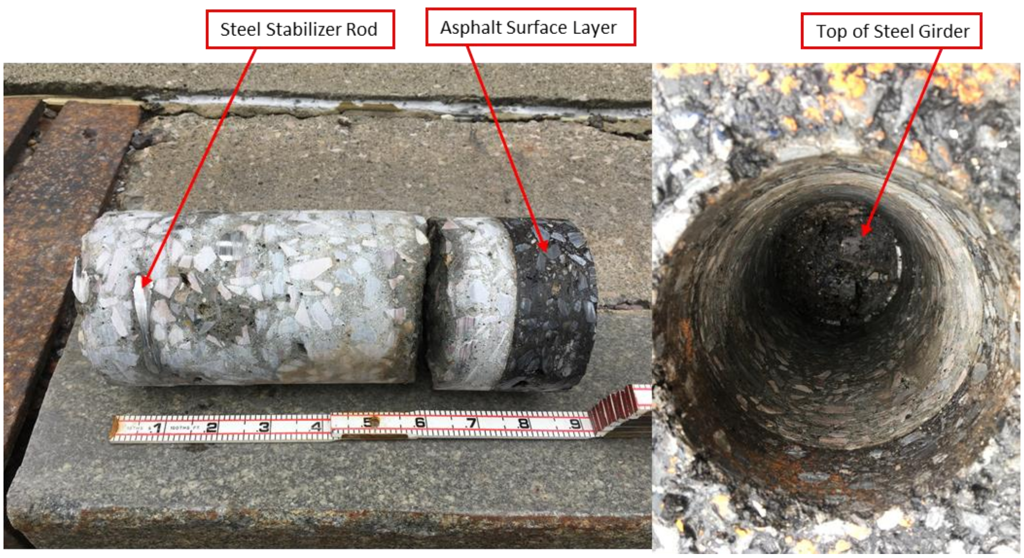


Figure 9: Area 1, L3 4in Diameter Core is Pictured on the Left. The Top of the Steel Girder Can Be Seen on the Image on the Right with no Shear Studs Visible. (Ruler in tenths of feet)

Figure 10: Area 1, L5 4in Core. Cannot Be Seen in the Image but Had 2 Rebar Meshes were Present.

Figure 11: Area 1, L6 6in Core. Vertical Rebar was Present Which Can Be Seen in Both Images. A 6in Core had to be cut Around the 4in Core Because the Drill Bit was Cutting into the Vertical Rebar.

Figure 12: Photos of a Vertical Rebar Found within L6 Core. It's a Mesh Seat Used to hold the Rebar Meshes in Place During Construction.

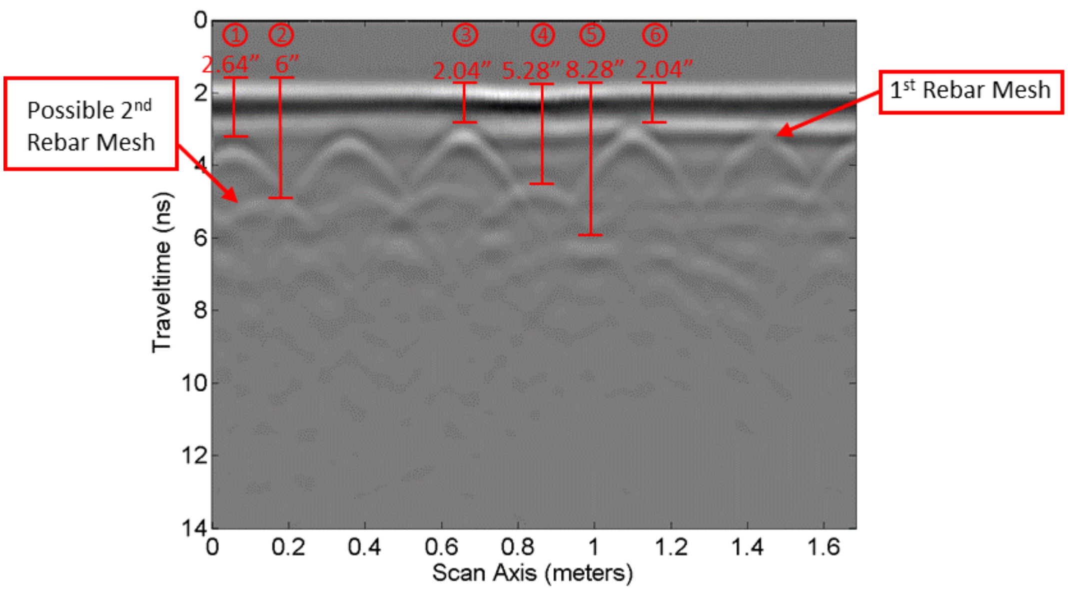


Figure 13: GPR Image (File 137), corresponds to a GPR scan on Area 2 on Bridge 77. Perpendicular to steel bridge deck girder.

Figure 14: Area 2 GPR Scanning Layout.

Figure 15: Drilling 6in Cores at Area 2 on Bridge 77.

Figure 16: Area 2 Coring Holes on Bridge 77.

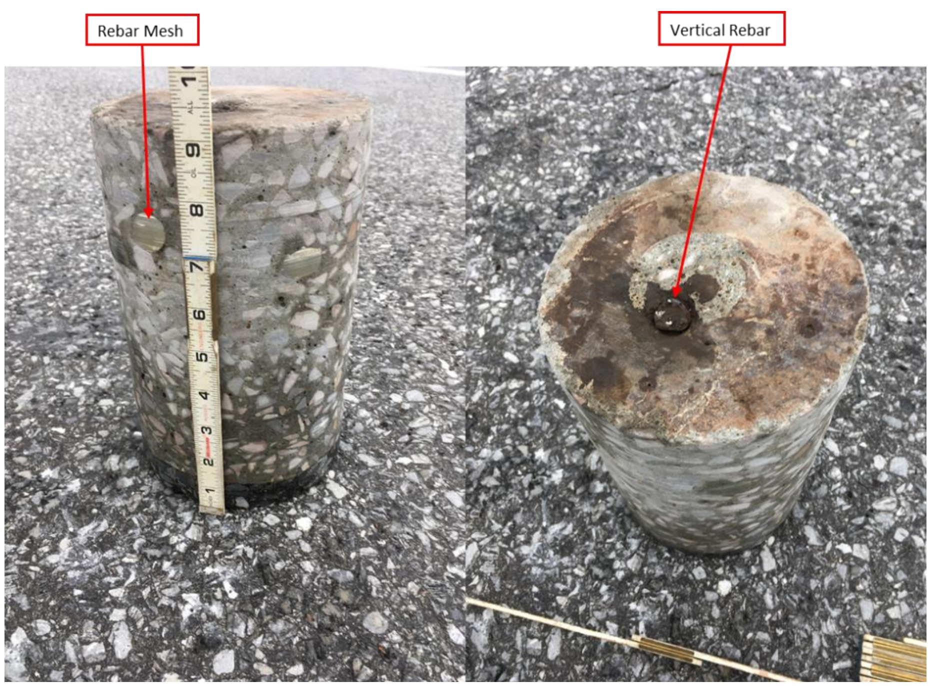


Figure 17: Area 2, L1 6in Core. The Image on the Left Depicts the Rebar Meshes within the Bridge Deck. The Image on the Right Shows the Bottom of the L1 Concrete Core Which Rested on the Top of the Steel Girder. The Vertical Rebar was Tacked onto the Steel Girder.

Figure 18: Area 2, L2 Core on Bridge 77. Rebar Meshes were Present.

Figure 19: Area 2, L3 Core on Bridge 77. Rebar Meshes were Present.

Figure 20: Coring Holes from Area 2, L1 (Left) and L3 (Right). Tacking Material from the Vertical Rebars can be Seen on the Top Surface of the Steel Girder.

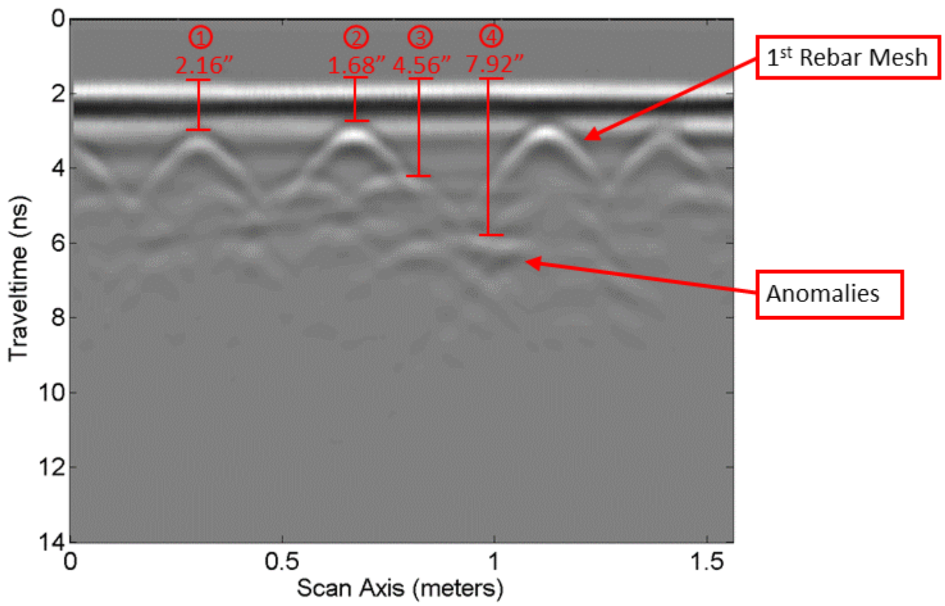


Figure 21: GPR Image (File 138), corresponds to a GPR scan on Area 3 on Bridge 77. Perpendicular to steel bridge deck girder.

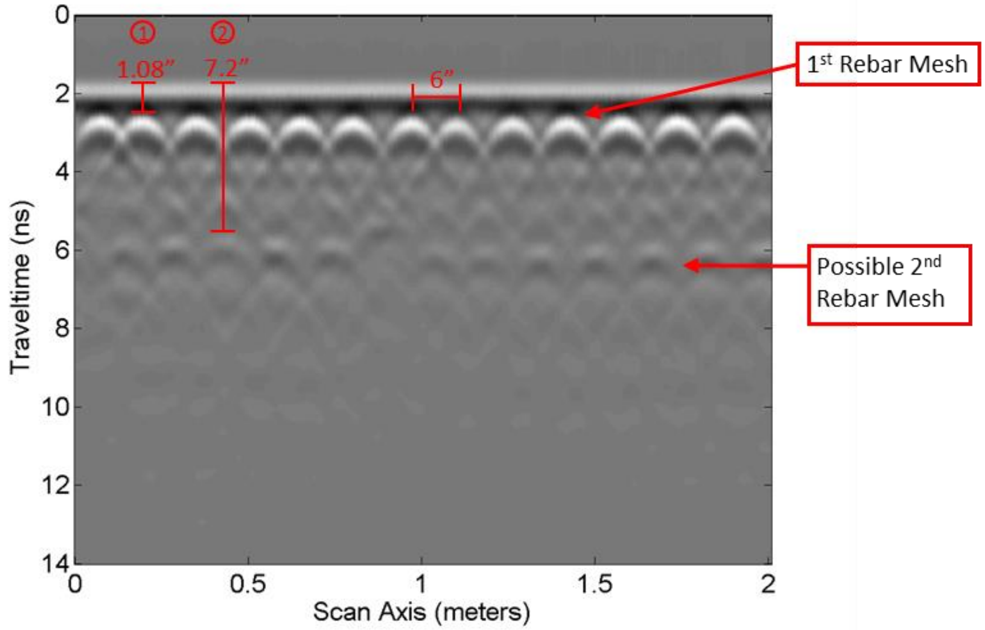


Figure 22: GPR Image (File 139), corresponds to a GPR scan on Area 3 on Bridge 77. Parallel to steel bridge deck girder.

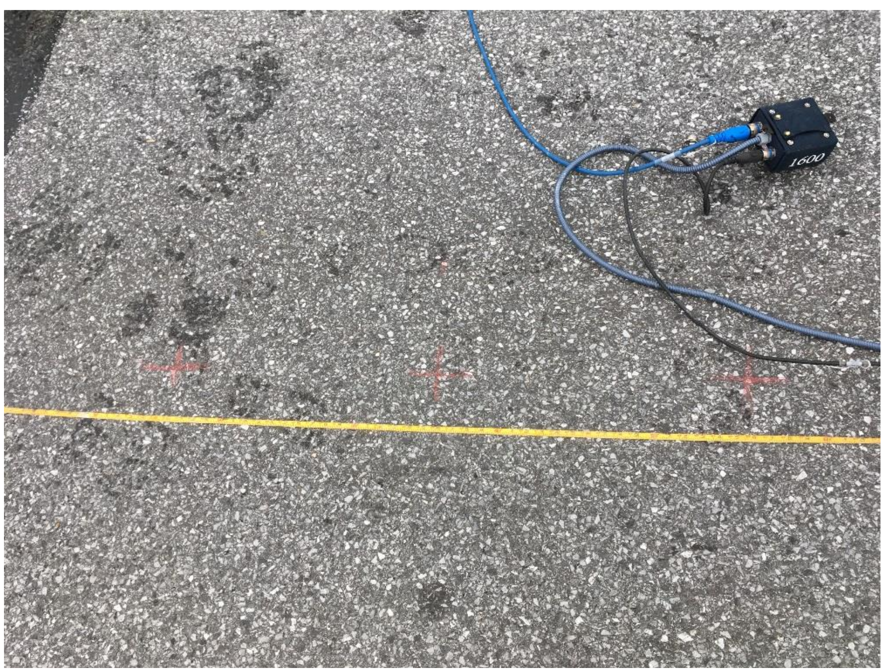


Figure 23: Area 3 GPR Scanning Layout on Bridge 77.

Date: Wednesday, November 16, 2016

Time: 8:00 AM to 12:00 PM

Weather: 50˚F, Light Rain

A field study to determine the effectiveness of GPR to locate shear studs in concrete bridge decks was conducted on southbound bridges 76 and 77, near the town of Colchester on US I-89. A field visit was conducted on the bridge 76 (southbound) near mile marker 95.307. The location of bridge 76 can be seen in Figures (24 & 25). VHB was interested in determining the presence of shear studs because their presence dictates the type, method and cost of bridge deck reclamation needed for a future construction project. Observations, photos, and notes were taken during the site visit. The objective of this study was to determine if GPR could be used as a supplemental technology to effectively determine the presence and location of shear studs on a bridge deck, decreasing the number of cores that need to be drilled to visually determine the presence of shear studs.

Figure 24: Topographic View of Bridge 76 on I-89 at MM 95.307 (Google Maps)

Figure 25: Street View of Bridge 77 on I-89 at MM 96.566 (Google Maps)

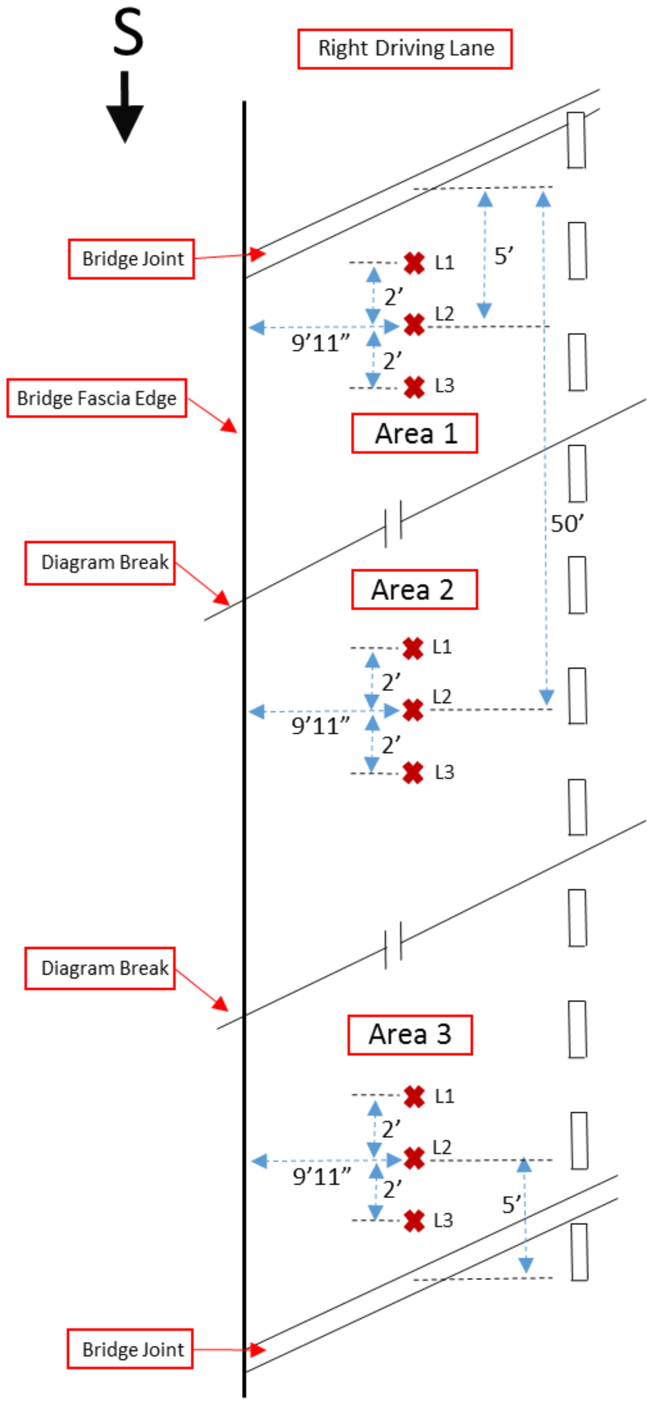


Figure 26: I-89 Bridge 76 Core Drilling Diagram Near Colchester

Field Notes & Observations:

It should be noted that 9 cores were drilled on bridge 76. Three test areas were designated throughout the span of bridge 76. The test areas were chosen by VHB engineers. Before the cores were drilled, the drilling layout was marked out and the GPR scans were conducted. The layout on bridge 76 is shown in Figure (26). The simplistic three cores per area layout is more efficient, due to the larger drilling bit reducing the error of missing the steel girder. The cores in Area 1 were drilled in ascending order; L1, L2, L3.

Core Sample and GPR Image Analysis

No GPR scans were conducted at Area 1 on bridge 76, due to the events that occurred on November 1st, 2016. As previously stated, on that day the drilling crew was having difficulties drilling the cores and the threshold rod on the drilling rig broke while drilling out the L2 core. The drilling bit became lodged within the bridge deck and could not be removed. The bit had to be cut with a torch, leaving a part of the bit within the concrete bridge deck. Pictures were not taken of the cores at Area 1. A quick inspection of the L1 and L3 cores showed that the two rebar mashes were present with no evidence of shear bolts. No core data was gathered from the L2 core because the drilling rig broke and the core could not be extracted from the concrete bridge deck.

Figure (27) [File 142], corresponds to the GPR scan at Area 2 on bridge 76. The scan was from the white shoulder line to the middle of the travel lane (perpendicular to the steel girders) and went into a puddle, which can be seen in Figure (28). There is a clear distinction on the scan image (greater contrast) when the GPR was in the puddle. A very bright surface reflection is present where the GPR went in the puddle, which can be seen in the upper right of the Figure. The GPR scan clearly shows the 1st rebar mesh at an approximate depth of 2.5 – 3.75”, which nicely correlates to the actual 1st mesh depth from the core sample in Figure (29). Evidence of a 2nd rebar mesh was most likely not evident in the scan image due to the high moisture content within the roadway, which dissipated the electromagnetic energy emitted by the GPR unit into the subsurface material. This occurs because water has a higher relative permittivity value compared to air, concrete or asphalt. Relative permittivity is a material property that describes the decrease in the electric field between charges relative to a vacuum and is a measurement used to differentiate materials.

Bridge 76 Area 2 cores can be seen in Figures (29 – 32). All three cores at Area 2 were drilled using a 6” drill bit. The 1st rebar mesh was at 3.5” and the 2nd rebar mesh was at 8” for cores L1, L2 and L3 in Area 2. The depth of the cores and the locations of the rebar meshes can be seen in Figures (29, 31 & 32). All cores in Area 2 show no evidence of shear studs.

Figures (33 & 34) [Files 143 & 144], correspond to GPR scans at Area 3 on bridge 76. Looking at the GPR scan shown in Figure (33), the 1st rebar mesh was visible but it was difficult to see any subsurface features below 5”. This is most likely due to the dielectric properties of the concrete bridge deck being saturated with rain water. The rain water scatters and reflects the electromagnetic radiation emitted from the GPR, penetrating less into the concrete bridge deck. A very bright surface reflection can be seen in the GPR scan in Figure (33). The scan was taken from the white shoulder line to the middle of the travel lane, running perpendicular to the steel girder. The scan depicted in Figure (34) ran parallel to the steel girder along the drilling layout, which ran a length of approximately 5.7’. The 1st rebar mesh can be clearly seen at a depth of about 1.5 - 2”. It is more difficult to see the 2nd rebar mesh because of the amount of backscatter and energy absorption the high moisture content at a depth of approximately 6.5 – 7.5”.

Bridge 76 Area 3 cores can be seen in Figures (35 – 39). All three cores at Area 3 were drilled using a 6" drill bit. The 1st rebar mesh was at 3.5" and the 2nd rebar mesh was at 7.5" for the L1 core. The 1st rebar mesh was at 3" and the 2nd rebar mesh was at 7" for the L3 core. The depth of the cores and the locations of the rebar meshes can be seen in Figures (37 & 38). The core at L2 was destroyed because the core became lodged within the drill bit. All cores in Area 3 show no evidence of shear studs.

Photos:

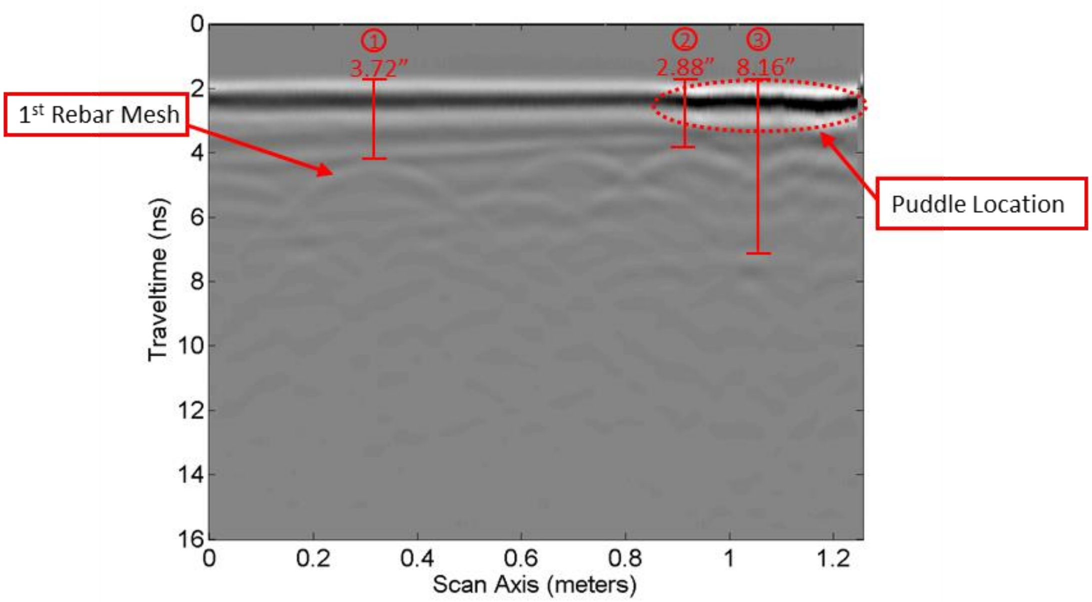


Figure 27: GPR Image (File 142), corresponds to a GPR scan on Area 2 on Bridge 76. Perpendicular to steel bridge deck girders.

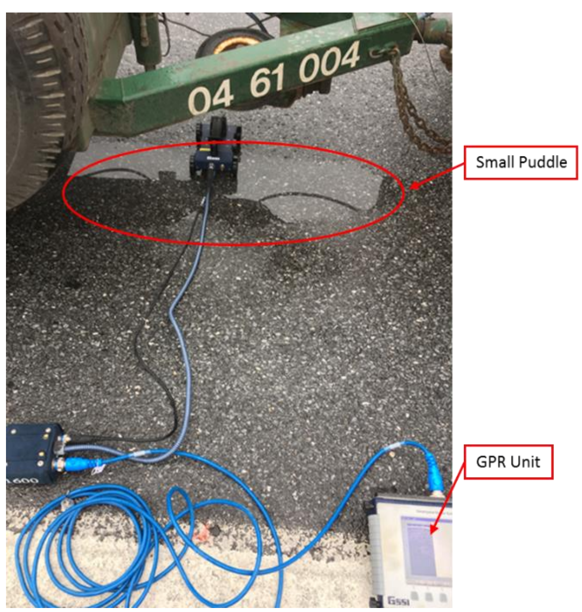


Figure 28: GPR Scan Near Area 2 on Bridge 76. Scanned through Puddle.

Figure 29: Core at Location 2 (L2) from Area 2 on Bridge 76.

Figure 30: Core Hole at Area 2 on Bridge 76.

Figure 31: Core at Location 1 (L1) from Area 2 on Bridge 76.

Figure 32: Core at Location 3 (L3) from Area 2 on Bridge 76.

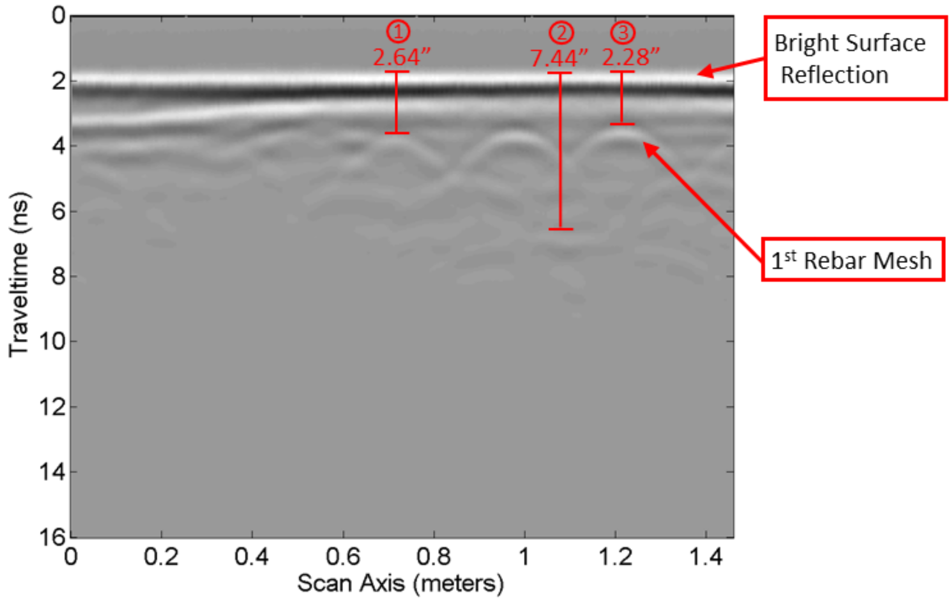


Figure 33: GPR Image (File 143), corresponds to a GPR scan on Area 3 on Bridge 76. Perpendicular to steel bridge deck girders.

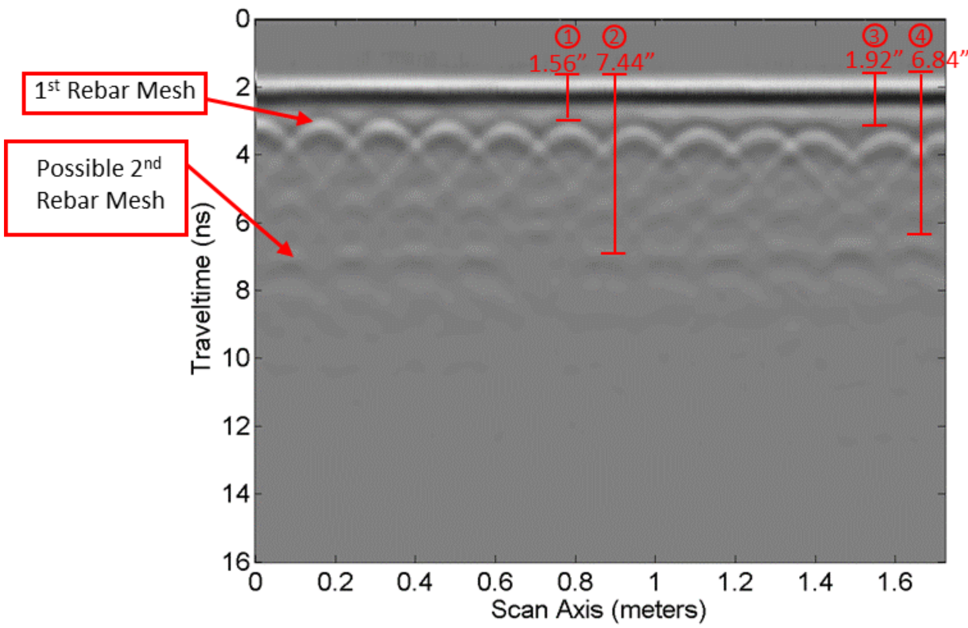


Figure 34: GPR Image (File 144), corresponds to a GPR scan on Area 3 on Bridge 76. Parallel to steel bridge deck girders.

Figure 35: Bridge 76 Area 3 Drilling Layout.

Figure 36: GPR Scan Path (Parallel to Roadway) on Bridge 76 at Area 3.

Figure 37: Core at Location 1 (L1) from Area 3 on Bridge 76.

Figure 38: Core at Location 3 (L3) from Area 3 on Bridge 76.

Figure 39: Core Holes on Bridge 76 at Area 3

Conclusion and Summary:

The objective of this study was to determine if Ground Penetrating Radar (GPR) could be used as a supplemental technology to effectively determine the presence and location of shear studs on a bridge deck. The use of this non-destructive evaluation method should decrease the number of cores that need to be drilled to visually determine the presence of shear studs. From the field observations and analysis on GPR scans, it can be concluded that the GPR technology (GSSI StructureScan) can locate subsurface elements and aid in drilling cores on bridge decks. Unfortunately, this study was inconclusive in determining the effectiveness of GPR in locating shear stubs. This is because both bridge 76 & 77 turned out not to have any shear studs, when they were initially called out in the construction plans, see Figure (43) in *Appendix I*. This was evident when analyzing the core samples from the bridges and can be seen in the figures. The only vertical members that were found during the study were the vertical rebars that can be seen in Figures (11 & 12), which were used as mesh seats to properly insure the depths of the two rebar meshes. From the initial analysis and from the GPR Scan images, Figures (6 & 7), it was unclear if the GPR unit could detect the vertical rebar members. This is because no significant subsurface anomaly was present in the figures near the interface between the asphalt paving surface and the concrete bridge deck, which may be due to the small cross-sectional area of a vertically placed rebar.

The GPR unit was very successful in determining the presence and spacing of the 1st rebar mesh at a depth of 1 – 6’’ below the asphalt surface. The GPR scans clearly show the differences in the rebar spacing between the rebar running perpendicular to the flow of traffic and parallel to the flow of traffic. The GPR scans show the spacing of the rebar to be approximately 6” intervals parallel to the flow of traffic and at approximately 12” intervals perpendicular to the flow of traffic, which can be seen in Figures (6 & 7).

Determining the depth and presence of the 2nd rebar was more difficult. In a number of GPR scans a faint signal of the 2nd rebar mesh could be seen at a depth of 5 – 9.5”. A clear example can be seen in Figures (6, 13, 21, 27 & 33). It is difficult to determine if these responses correlate directly to the 2nd rebar mesh, due to their variability in depth and how faintly they show up on the images. It should be mentioned that the contrast of the scan images was enhanced post processing to better identify the 2nd rebar mesh. The GPR Unit does have options to enhance the images out in the field, but they were not utilized for this investigation due to time constraints. For Figures (6, 13, 21, 27 & 33), it was difficult to correlate to the depth of the 2nd rebar mesh on the GPR scan to the measured location of the rebar from the core samples. The detection of the 2nd rebar mesh by the GPR Unit could be verified by the core samples, when the scans were conducted parallel to the steel girders. This is evident when analyzing the GPR scan in Figure (34) to the core samples from Area 3 of bridge 76 in Figures (37 & 38). The scan image shows that the 2nd mesh lies at a depth between 6.8 -7.5” while the core samples verify that the 2nd rebar mesh was at a depth of 7” at the L1 and L3 locations. The GPR scans in Figures (7, 21 & 22) cannot be properly verified by the area core samples because there was insufficient data, because the Research Section was not on site to take measurements on Area 3 cores on bridge 77. The data gathered from core samples in Area 1 on bridge 77 seemed inconsistent to the GPR scan in Figure (7).

The image of the 2nd rebar mesh might have been altered due to a variety of different variables that decrease signal strength as it penetrates the material. The rebar spacing of the 1st mesh limits the amount of signal that can keep penetrating further into the concrete deck and reflect off the 2nd rebar mesh. Backscatter from boundary layers, the 1st rebar mesh and other subsurface anomalies can also hide or distort subsurface features of interest, like the 2nd rebar mesh or shear studs. Changes in the dielectric properties of the concrete can also change the GPR scan image if the scan settings on the GPR unit are not updated. This event occurred when it rained, adding moisture to the concrete and creating surface puddles, which can be seen in Figure (27). A stronger surface reflection was noted and the hyperbolas that determine the presence of rebar were much fainter.

Further research and field testing of the GPR unit, on a bridge where shear studs are known to be present, need to be conducted to accurately determine the effectiveness of GPR in detecting shear studs. The Research Section believes that the current field testing shows the potential and effectiveness of GPR technology for locating subsurface elements such as rebar, air voids and material boundary layers. The Research Section's GSSI StructureScan GPR unit has many capabilities and settings that were not explored during the study. This includes but is not limited to, 3D GPR imaging and changing the dielectric property settings that with future testing and experimentation could further increase the effectiveness and utilization of GPR throughout the Vermont Agency of Transportation.

Appendix I

Colchester IM 089 3(69) Bridge 76 and 77 Plans

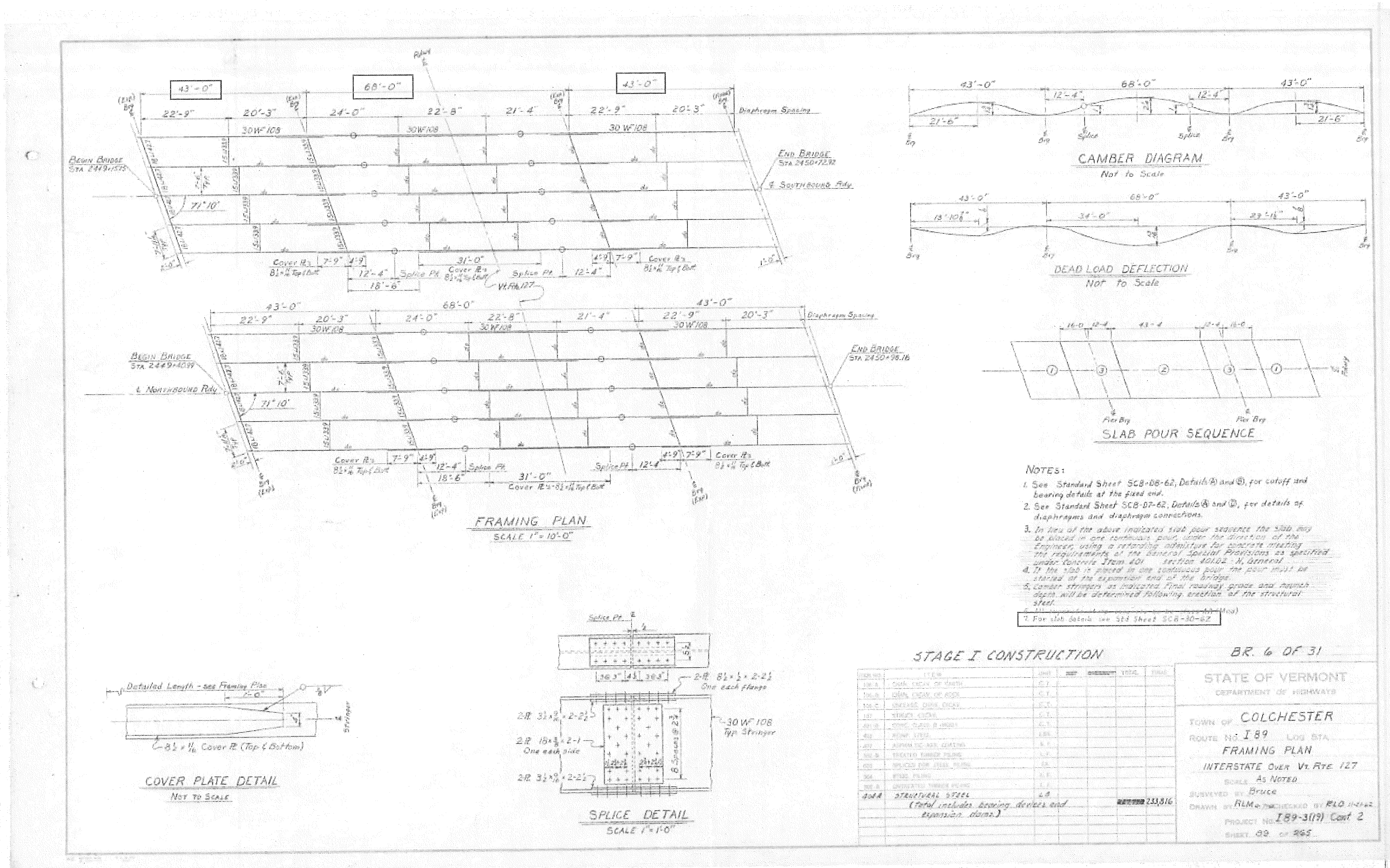
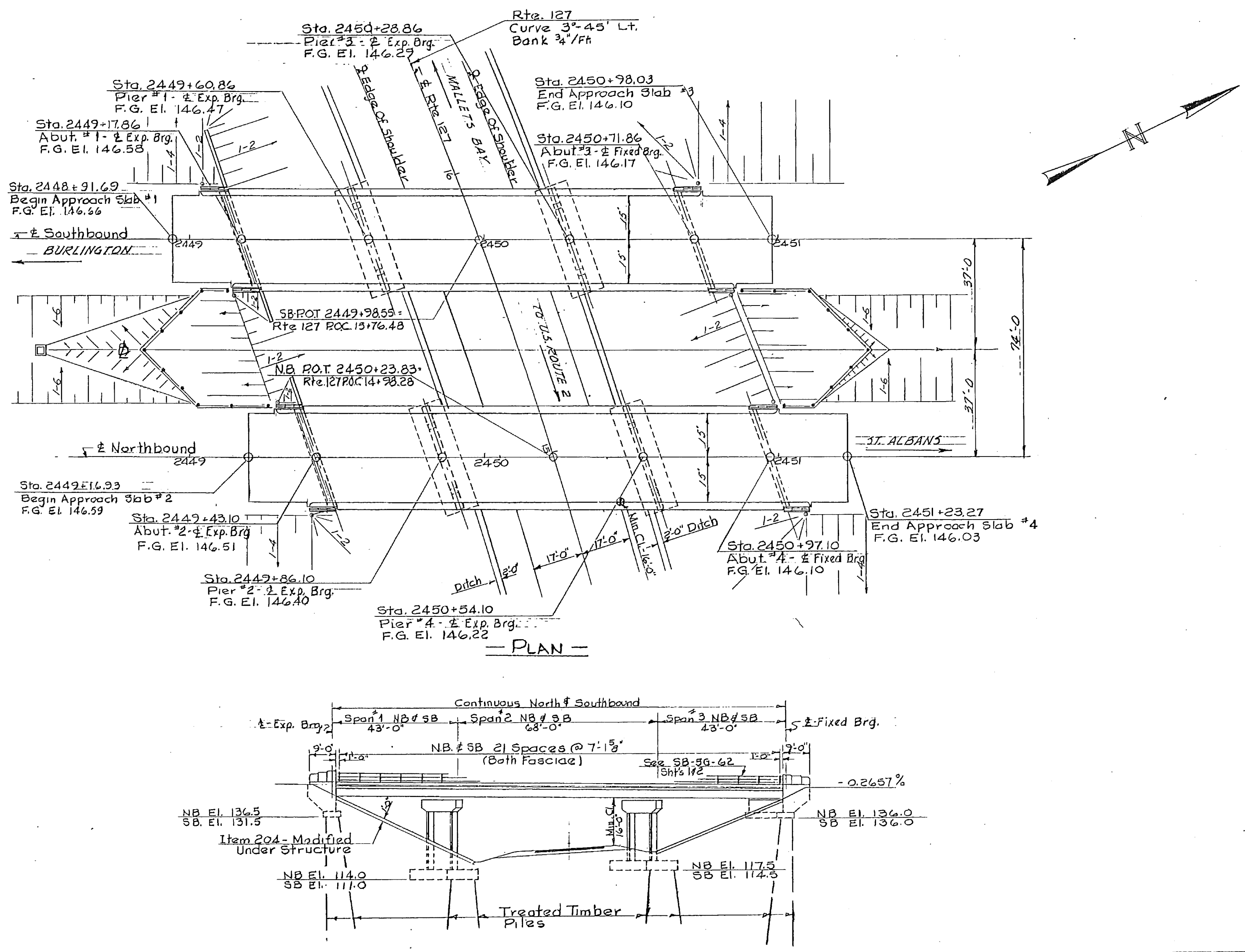


Figure 40: Colchester IM 089 3(69) - Bridge 76 (Page 1)



— ELEVATION —

GENERAL NOTES

1- Elevation datum sea level based on nearest U.S. Government Vertical Control.
2- For additional notes see S.C.B-D1-62.
3- Approach slabs shall be constructed as part of Stage II construction.
4. If abuts. are in fill, fill is to be made to pile Cut-off Elev. prior to driving piles. Excav. to Bot. of Ftg. Elev. after driving piles to be paid under Item 107.

— LIST OF BRIDGE SHEETS —

BR-1	Plan & Profile Of Roadway
BR-2	Plan & Elevation Of Bridge
BR-3	Quantities
BR-4	Preliminary Information
BR-5	Borings
BR-6	Framing Plan
BR-7	Abutment #1
BR-8	" #2
BR-9	Abutments #3 & #4
BR-10	Piers #1, 2, 3, & 4
BR-11	Expansion Dams
BR-12	Bearing Devices
BR-13,14	Reinforcing Steel Schedule
BR-15,16	Cross Sections Of Interstate
BR-17	Plan & Profile Of Rte. 127
~~BR-18,19~~	~~Cross Sections Of " "~~
BR-20	Standard Sheet SCB-30-62
BR-21-27	" " SCB-D1,2,4,6,7,8,9,-62
BR-28,29	" " SB-5G-62
BR-30,31	" " SB-AS-62

STAGE II CONSTR.

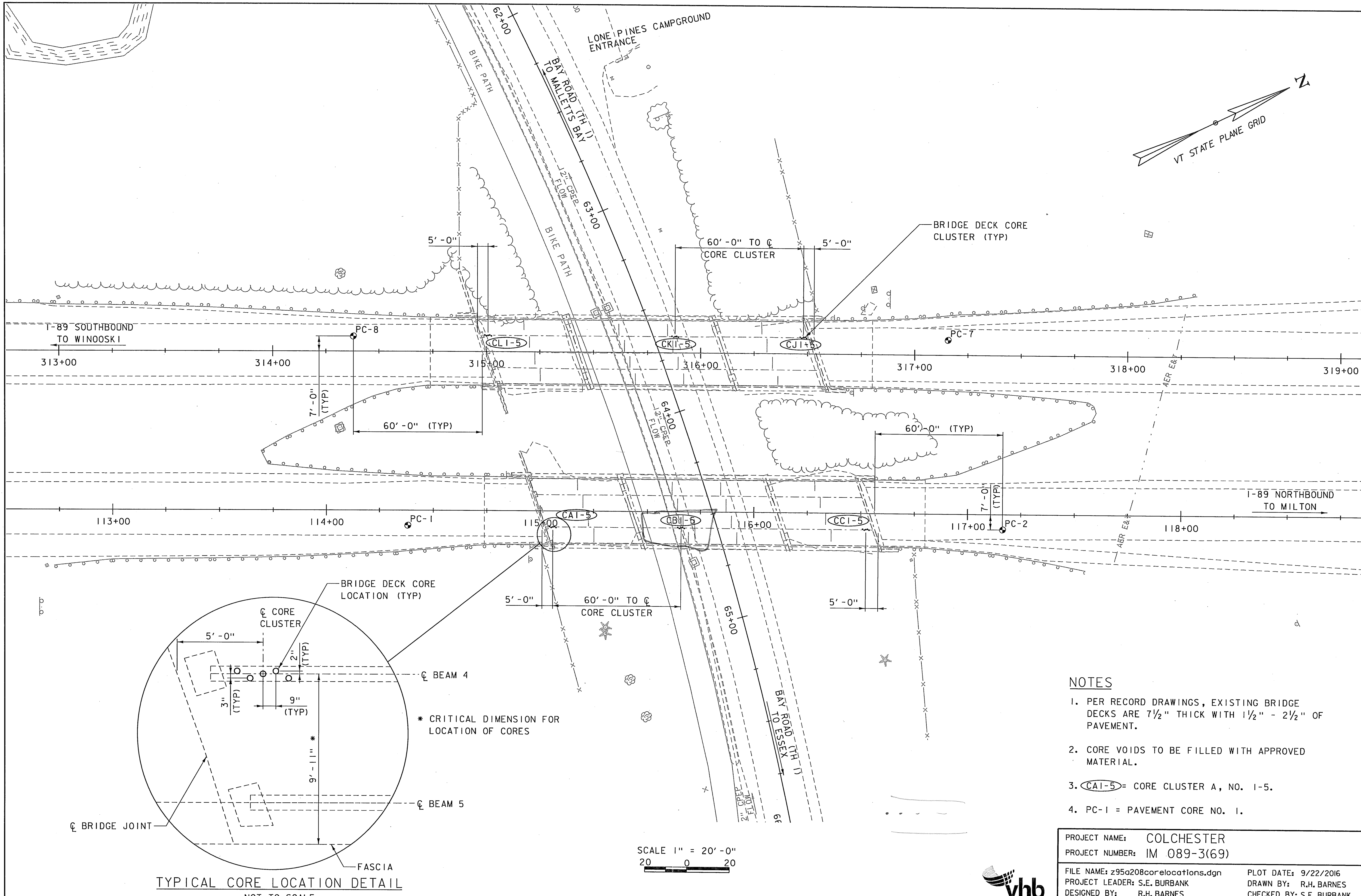
BR. 2 OF 31

ITEM NO.	ITEM	UNIT	NET	OVERRUN	TOTAL	FINAL
106-A	CHAN. EXCAV. OF EARTH	C.Y.				
106-B	CHAN. EXCAV. OF ROCK	C.Y.				
106-C	UNCLASS. CHAN. EXCAV.	C.Y.				
107	STRUCT. EXCAV.	C.Y.				
401-B	CONC. CLASS B (MOD.)	C.Y.				
402	REINF. STEEL	LBS.				
407	ASPHALTIC-ASB. COATING	S.Y.				
502-B	TREATED TIMBER PILING	L.F.				
503	SPLICES FOR STEEL PILING	EA.				
504	STEEL PILING	L.F.				
502-A	UNTREATED TIMBER PILING	L.F.				

STATE OF VERMONT
DEPARTMENT OF HIGHWAYS

TOWN OF COLCHESTER
ROUTE NO. I-89 ~~I-89-3(9)~~
PLAN & ELEVATION OF INT.
OVER Rte. 127
SCALE 1"=20'
SURVEYED BY Bruce
DRAWN BY NBT CHECKED BY RLO
PROJECT NO. I-89-3(29)
SHEET 79 OF 265 CONTR. #1
#85(19)2/2

Figure 41: Colchester IM 089 3(69) - Bridge 76 (Page 2)



TYPICAL CORE LOCATION DETAIL

NOT TO SCALE

NOTES

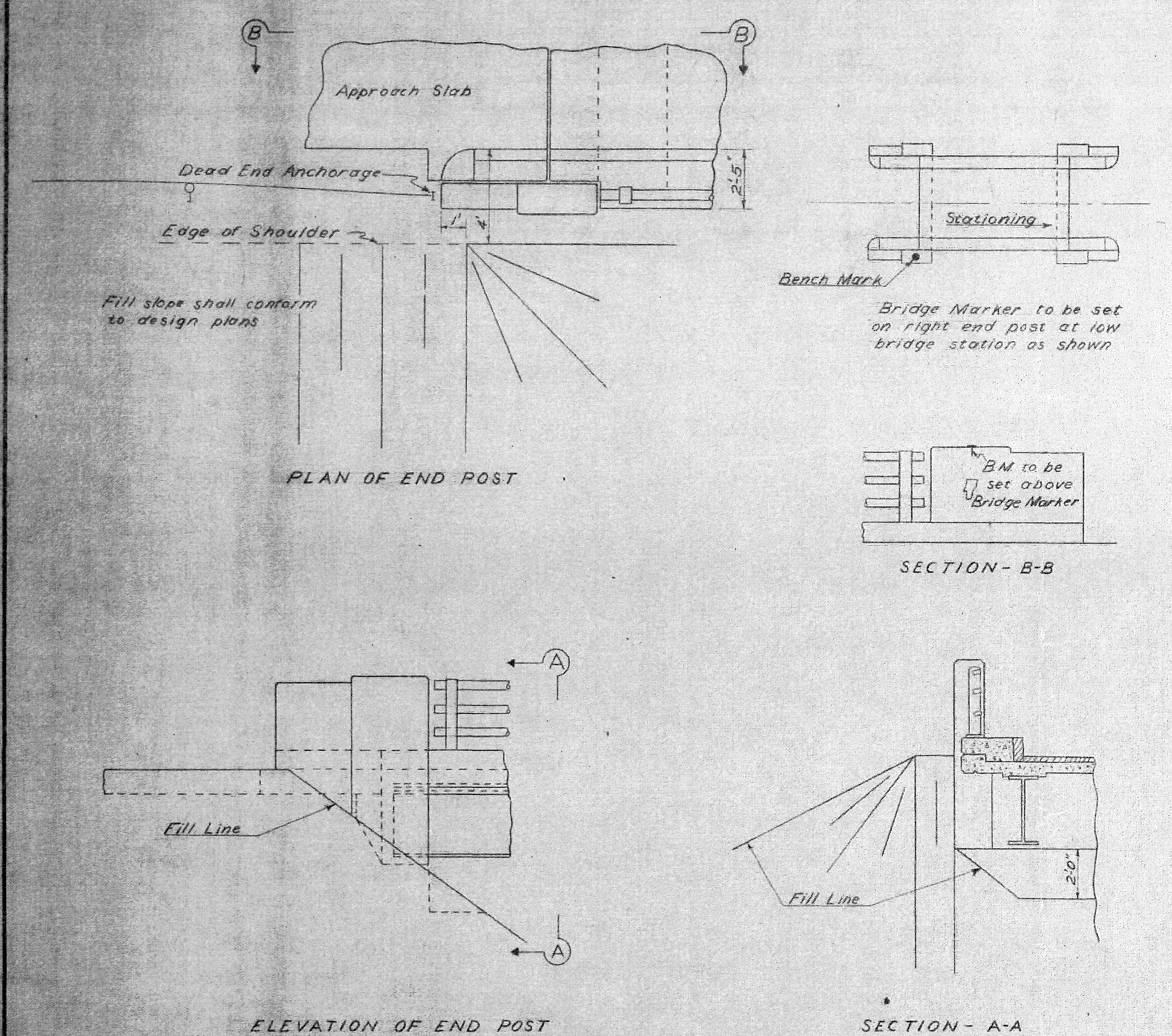
1. PER RECORD DRAWINGS, EXISTING BRIDGE DECKS ARE 7½" THICK WITH 1½" - 2½" OF PAVEMENT.
2. CORE VOIDS TO BE FILLED WITH APPROVED MATERIAL.
3. CA1-5 = CORE CLUSTER A, NO. 1-5.
4. PC-1 = PAVEMENT CORE NO. 1.

vhb

PROJECT NAME: COLCHESTER	
PROJECT NUMBER: IM 089-3(69)	
FILE NAME: z95a208corelocations.dgn	PLOT DATE: 9/22/2016
PROJECT LEADER: S.E. BURBANK	DRAWN BY: R.H. BARNES
DESIGNED BY: R.H. BARNES	CHECKED BY: S.E. BURBANK
CORE LAYOUT SHEET (BR. NO. 76 N&S)	SHEET 1 OF 2

Figure 42: Colchester IM 089 3(69) - Bridge 76 (Page 3)

VHB 57804



GENERAL NOTES

SPECIFICATIONS: ALL MATERIALS AND CONSTRUCTION SHALL CONFORM TO THE STATE OF VERMONT, DEPARTMENT OF HIGHWAYS, STANDARD SPECIFICATIONS FOR HIGHWAY AND BRIDGE CONSTRUCTION DATED JANUARY 1956, AND THE A.A.S.H.O. STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES DATED 1961.

DESIGN IS FOR H20-S16-44 LOADING MODIFIED FOR THE NATIONAL SYSTEM OF INTERSTATE HIGHWAYS, APPLIED IN ACCORDANCE WITH THE PROVISIONS OF THE A.A.S.H.O. STANDARD SPECIFICATIONS, ARTICLE 1.2.8.

STRUCTURAL STEEL: UNLESS OTHERWISE NOTED ON THE PLANS ALL STRUCTURAL STEEL SHALL CONFORM WITH A.S.T.M. DESIGNATION A-36-62 T.

UNLESS OTHERWISE DETAILED ALL FIELD CONNECTIONS SHALL BE MADE WITH 7/8" Ø HIGH STRENGTH BOLTS, USING 15/16"Ø HOLES. WHERE CONNECTIONS ARE NOT DETAILED ON THE PLANS, THEY SHALL BE DETAILED BY THE FABRICATOR AND SUBMITTED TO THE STATE FOR APPROVAL.

DETAILS OF SHEAR CONNECTORS SHALL BE SUBMITTED TO THE STATE FOR APPROVAL. EITHER CHANNEL OR STUD CONNECTORS MAY BE SUBSTITUTED IN LIEU OF THE SPIRAL. STUDS SHALL BE SUBSTITUTED ON THE BASIS OF TWO (2) 3/4" STUD FOR EACH PITCH OF A 5/8" Ø SPIRAL, OR ON THE BASIS OF TWO (2) 7/8" STUDS TO 1 1/2 TIMES THE PITCH OF A 5/8" Ø SPIRAL.
NO SCUPPERS SHALL BE USED ON GRADE SEPARATIONS UNLESS INDICATED ON THE PLANS.

ON SUPERELEVATED BRIDGES, PLACE SCUPPERS ON THE LOW SIDE ONLY. EXCEPT FOR THE ABOVE RESTRICTIONS, SCUPPERS ARE NORMALLY PLACED MIDWAY BETWEEN INTERMEDIATE DIAPHRAGMS. PAYMENT FOR SCUPPERS SHALL BE INCLUDED IN THE UNIT PRICE FOR STRUCTURAL STEEL, ITEM 404.

UNLESS OTHERWISE CALLED FOR, BEAMS SHALL BE CAMBERED TO THE MINIMUM CAMBER LIKELY TO REMAIN PERMANENT AS INDICATED IN THE A.I.S.C. HANDBOOK. THE CAMBER SHALL APPROXIMATE A SIMPLE CIRCULAR CURVE FROM END TO END OF BEAM. TOLERANCES IN CAMBER SHALL BE AS INDICATED IN THE A.I.S.C. HANDBOOK.

AFTER THE SUPERSTRUCTURE STEEL HAS BEEN ERECTED, ELEVATIONS OF THE TOP OF THE ERECTED BEAMS SHALL BE TAKEN UNDER THE DIRECTION OF THE ENGINEER TO DETERMINE THE FINAL GRADE.

PAINT: THE FINAL COAT OF FIELD PAINT SHALL BE GREEN, UNLESS OTHERWISE DIRECTED BY THE ENGINEER.

CONCRETE: ALL CONCRETE IN THE SUPERSTRUCTURE SHALL BE CLASS A A(MOD) ALL EXPOSED EDGES OF CONCRETE SHALL BE CHAMFERED 1" X 1" UNLESS OTHERWISE INDICATED ON THE PLANS.
CONSTRUCTION JOINTS SHALL BE AS INDICATED ON THE STANDARDS UNLESS OTHERWISE INDICATED ON THE PLANS.

REINFORCING STEEL: FOR SKEWED BRIDGES: TRANSVERSE BARS, "S 1" SHALL BE FURNISHED AS FOR A SQUARE SPAN; THE "S1" BARS SHALL BE CUT IN THE FIELD TO FIT THE SKEWED END, THE CUT-OFF BARS SHALL BE USED AT THE OPPOSITE END OF THE SPAN; THE S 5 BARS SHALL BE LENGTHENED AND THE NUMBER OF S6A AND S7 BARS SHALL BE INCREASED; THE S6P BARS SHALL BE ADDED AT PIERS AS INDICATED. MINIMUM COVER FOR REINFORCING STEEL, MEASURED FROM THE SURFACE OF THE CONCRETE TO THE FACE OF THE REINFORCEMENT, SHALL BE 3" UNLESS OTHERWISE SPECIFIED.

QUANTITIES: THE QUANTITIES GIVEN IN THE SCB-24 TO 44-62 STANDARDS ARE NET QUANTITIES FOR A SINGLE SQUARE SPAN.

GENERAL: NORMALLY THE FIXED END BEARING DEVICE IS ON THE DOWN-GRADE END OF THE SPAN. UNLESS OTHERWISE DESIGNATED ALL EXPANSION MATERIAL SHALL NOT CONTAIN ASPHALT OR BITUMINOUS MATERIAL AND IT SHALL CONFORM WITH A.A.S.H.O. DESIGNATION: M153 TYPE II.

ALL DIMENSIONS GIVEN ARE MEASURED HORIZONTALLY OR VERTICALLY UNLESS OTHERWISE NOTED.

BORINGS INDICATED ON THE DRAWINGS HAVE BEEN MADE FOR DESIGN PURPOSES ONLY AND ARE NOT WARRANTED TO SHOW ACTUAL SUB-SURFACE CONDITIONS.

TOP SURFACES OF ALL PIERS AND ABUTMENTS SHALL BE SLOPED 1/4" PER FOOT EXCEPT AT BEARING PADS, WHERE THE SURFACES SHALL BE LEVEL. ABUTMENTS SHALL BE SLOPED FROM THE FRONT EDGE OF THE CURTAIN WALL OF FACE OF BACKWALL, AND PIERS SHALL BE SLOPED FROM THE CENTERLINE OF PIER.

THE ENTIRE EXPOSED TOP SURFACE OF THE ABUTMENTS AND PIERS SHALL BE COATED WITH ASPHALTIC ASBESTOS COATING 1/2" THICK AS PER ITEM 407. THIS ITEM SHALL BE APPLIED AFTER ALL PAINTING AND INCIDENTAL ITEMS ARE COMPLETED.

ALL DIMENSIONS ARE GIVEN AT 68° F. UNLESS OTHERWISE NOTED.

WHERE BITUMINOUS CONCRETE PAVEMENT IS CALLED FOR AS A WEARING SURFACE ON BRIDGE DECKS AND APPROACH SLABS IT SHALL BE A DENSE GRADED TOP COURSE MATERIAL, APPLIED IN ONE COURSE, ONE AND ONE HALF (1 ½) INCHES THICK. THE ITEM TO BE USED SHALL BE DESIGNATED ON THE PLANS, EITHER AS ITEM 361-B OR ITEM 363.

PILES: STEEL PILES SHALL BE DRIVEN TO REFUSAL UNLESS OTHERWISE DIRECTED BY THE ENGINEER. WHERE PILES ARE DRIVEN IN FILL, THE MATERIAL SHOULD BE SUCH AS TO HAVE NO STONES LARGE ENOUGH TO INTERFERE WITH THE DRIVING OF PILES.

REVISIONS & CORRECTIONS

Drawn By: W Date: Dec. 1, 1962
Traced By: W Date: Dec. 1, 1962
Checked By: E.F.D. W.M.S. R.S.K. Date: Dec. 1, 1962
Recommended For Approval: [signature] Bridge Engineer 12/7/62 Date
Recommended For Approval: [signature] Assist. Chief Engineer 1/4/63 Date
Approved By: [signature] Chief Engineer 1/4/63 Date

DETAILS OF WF BEAM BRIDGES
GENERAL INFORMATION & GENERAL NOTES

VERMONT
DEPARTMENT OF HIGHWAYS
STRUCTURE STANDARDS
SCB-DI-62

241

Figure 43: Colchester IM 089 3(69) - Bridge Element Details (Page 4)

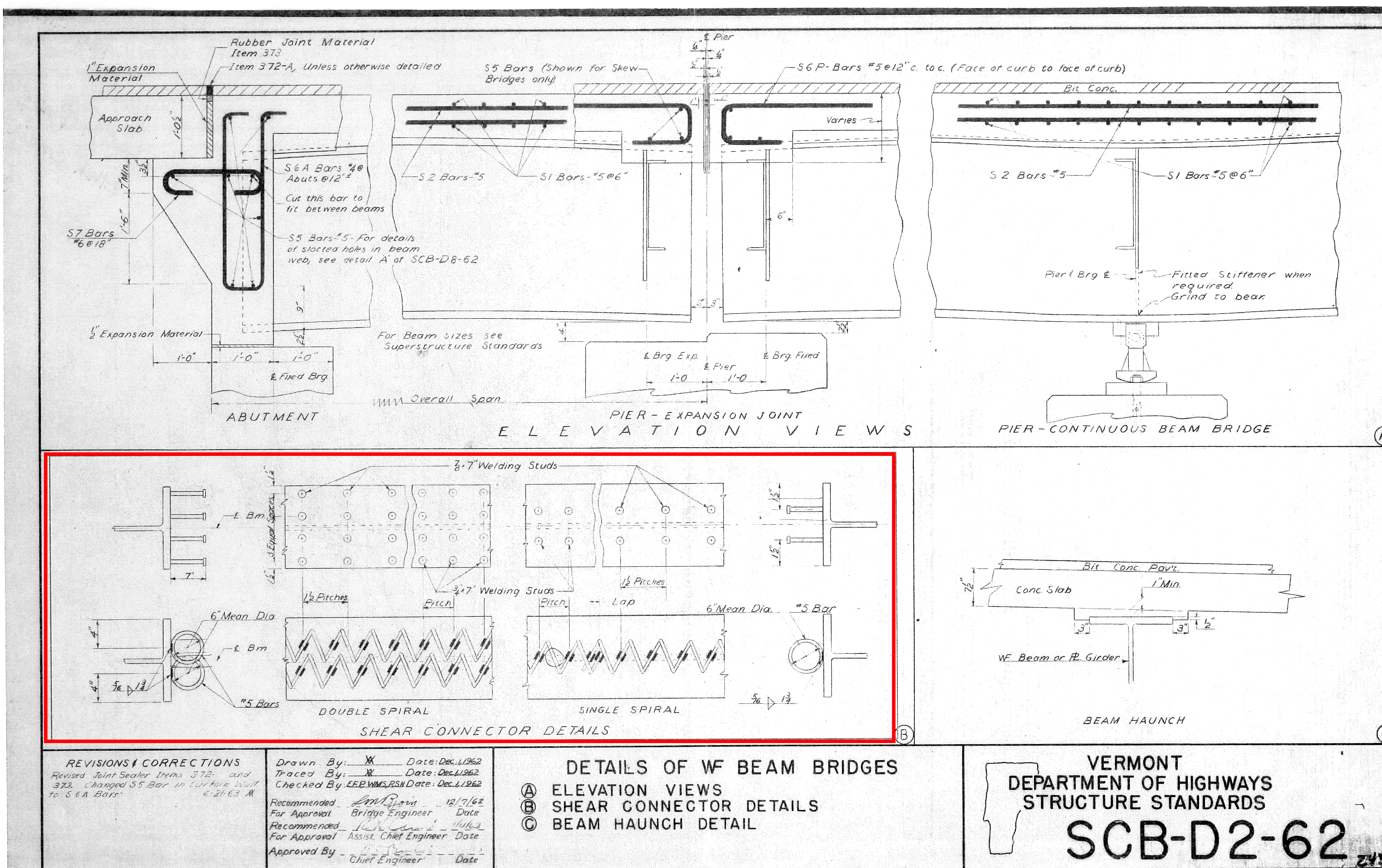
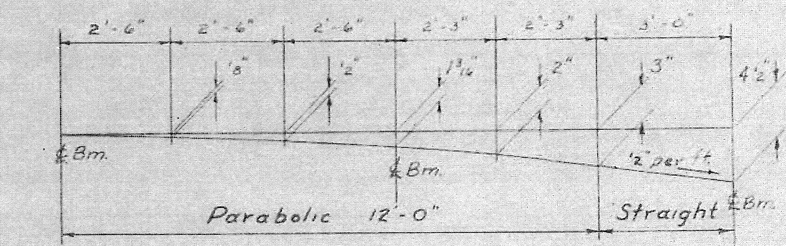
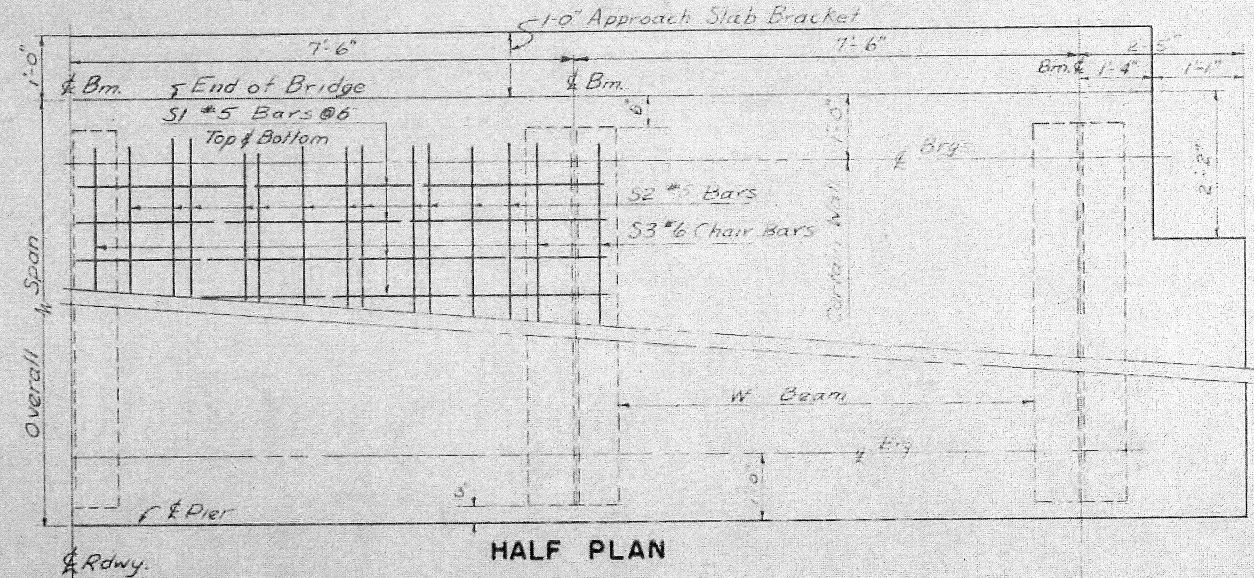


Figure 44: Colchester IM 089 3(69) - Bridge Shear Stud Details (Page 5)

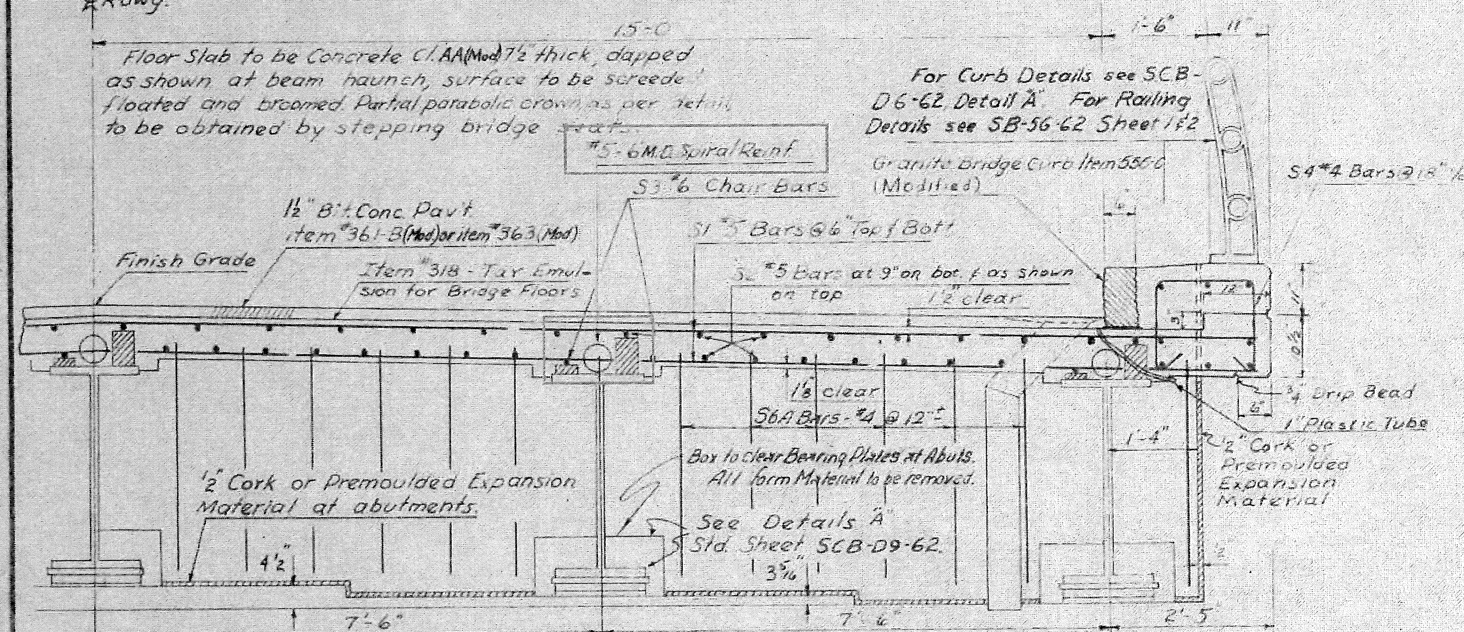
*Excluding Scuppers & Bearing Devices



DETAIL OF PARTIAL PARABOLIC CROWN OF SLAB



HALF PLAN



TYPICAL HALF SECTION

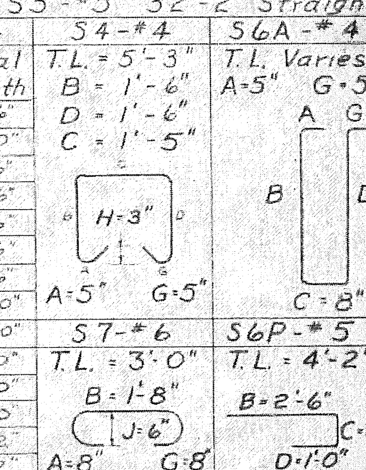
TABLE OF QUANTITIES FOR SINGLE (SQUARE) SPAN

Span, Out to Out	99-0	94-0	89-0	84-0	79-0	74-0	69-0	64-0	59-0	54-0	49-0	44-0	39-0	34-0
Span ℄ to ℄ Brngs.	97-0	92-0	87-0	82-0	77-0	72-0	67-0	62-0	57-0	52-0	47-0	42-0	37-0	32-0
Length of Bms.	98-0	93-0	88-0	83-0	78-0	73-0	68-0	63-0	58-0	53-0	48-0	43-0	38-0	33-0
Size WF Beam	36WF280	36WF245	36WF230	36WF230	36WF194	36WF170	36WF150	36WF135	36WF135	36WF135	36WF136	36WF135	33WF118	30WF108
Lgth & Size Cover Pl. (Bott. only)	66'-1" lg. 14"x1½"	65'-7" lg. 14"x1½"	59'-5" lg. 14"x1¼"	49'-5" lg. 14"x⅞"	49'-10" lg. 10"x1¼"	47'-7" lg. 10"x1⅛"	45'-9" lg. 10"x1"	42'-5" lg. 10"x⅞"	37'-11" lg. 10"x½"	27'-1" lg. 8"x½"	—	—	—	—
Dead Load Deflection	3½"	3⅛"	2⅝"	2¼"	1⅞"	1⅝"	1⅜"	1⅛"	⅞"	⅝"	½"	⅜"	¼"	¼"
Dia. of Spiral Bars	⅝"											Non Composite		
Mean Dia. of Spiral	6"											"	"	
Spiral Pitch 0'-10' from Brng.	Double @ 5½	Double @ 5½	Double @ 5½	Double @ 5½	Double @ 5	Double @ 5	Double @ 5	Double @ 5	Double @ 5"	Double @ 5½	Double @ 5½	"	"	
" " 10'-20' or ℄ Span	Double @ 6½	Double @ 6"	Double @ 6½	Double @ 7"	Double @ 7"	Double @ 7½	Double @ 7"	Double @ 7"	Double @ 7"	Double @ 7"	Double @ 7½	"	"	
" " 20'-30' or ℄ Span	4"	4"	4½	4½	4½	4½	4½	5"	5½	6"	6"	"	"	
" " 30'-40' or ℄ Span	5"	5"	5"	6"	6"	6"	6"	5"	—	—	—	"	"	
" " 40'-℄ Span	6½	6½"	6"	6"	—	—	—	—	—	—	—	"	"	
*Tot. Struct. Steel (1 span) (lbs.)	169,590	145,670	126,840	112,050	92,150	76,670	62,740	52,610	45,490	41,150	35,830	32,390	24,240	19,280
Reinforcing Bars ~ S1	[illegible]	376	356	336	316	296	276	[illegible]	236	216	196	176	156	136
" ~ S2	225	225	225	225	225	225	225	150	150	150	150	150	150	75
" ~ S3	30	30	30	30	30	30	30	20	20	20	20	20	20	10
" ~ S4	132	126	120	112	106	100	92	86	80	72	66	60	52	46
" ~ S5	16	16	16	16	16	16	16	16	16	16	16	16	16	16
" ~ S6A	52	52	52	52	52	52	52	52	52	52	52	52	52	52
" ~ S7	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Tot. Weight - Reinf. Bars (lbs.)	25,300	24,100	22,900	21,700	20,400	19,300	18,000	16,600	15,400	14,200	13,000	11,800	10,600	9,200
Approx. Wt. Spiral Reinf. (lbs.)	2,580	2,550	2,380	2,190	2,160	2,04	1,990	1,860	1700	1560	1440	Non Composite		
Tot. Cu. Yds. Conc. Class "AA" (Cu. yds.)	116	111	106	101	95	90	85	79	73	68	63	58	51	45
Tot. Wt. Bitum. Conc. Pavt. (Mod.) (Tons)	32	30	29	27	26	24	22	21	19	18	16	15	13	12
Tar Emulsion for Bridge Floors (Gals.)	132	125	119	112	105	99	92	85	79	72	65	59	52	45
Approx. Quantity ¾" x 7 Studs	3180	3,120	2,940	2,680	2,640	2,500	2,440	2280	2,120	1,900	1,760	Non Composite		
Approx. Quantity ⅞" x 7 Studs	2,110	2,080	1,960	1,790	1,760	1,670	1,630	1520	1410	1,270	1170	Non Composite		

REINFORCING STEEL SCHEDULE

S1 - #5 34'-4" Straight | S5 - #5 32'-2" Straight

Span	S2 - #5 Str. Length	S3 - #6 Str. Length	S6A - #4 B & D	S6A - #4 Total Length
34	33'-6"	33'-6"	2'-6"	6'-6"
39	20'-3"	20'-6"	2'-9"	7'-0"
44	22'-9"	23'-0"	3'-0"	7'-6"
49	25'-3"	25'-6"	3'-0"	7'-6"
54	27'-9"	28'-0"	3'-0"	7'-6"
59	30'-3"	30'-6"	3'-0"	7'-6"
64	32'-9"	33'-0"	3'-0"	7'-6"
69	24'-3"	24'-6"	3'-2"	7'-10"
74	26'-0"	26'-3"	3'-2"	7'-10"
79	27'-6"	28'-0"	3'-3"	8'-0"
84	29'-3"	29'-6"	3'-3"	8'-0"
89	31'-0"	31'-3"	3'-3"	8'-0"
94	32'-6"	33'-0"	3'-4"	8'-2"
99	34'-3"	34'-6"	3'-4"	8'-2"



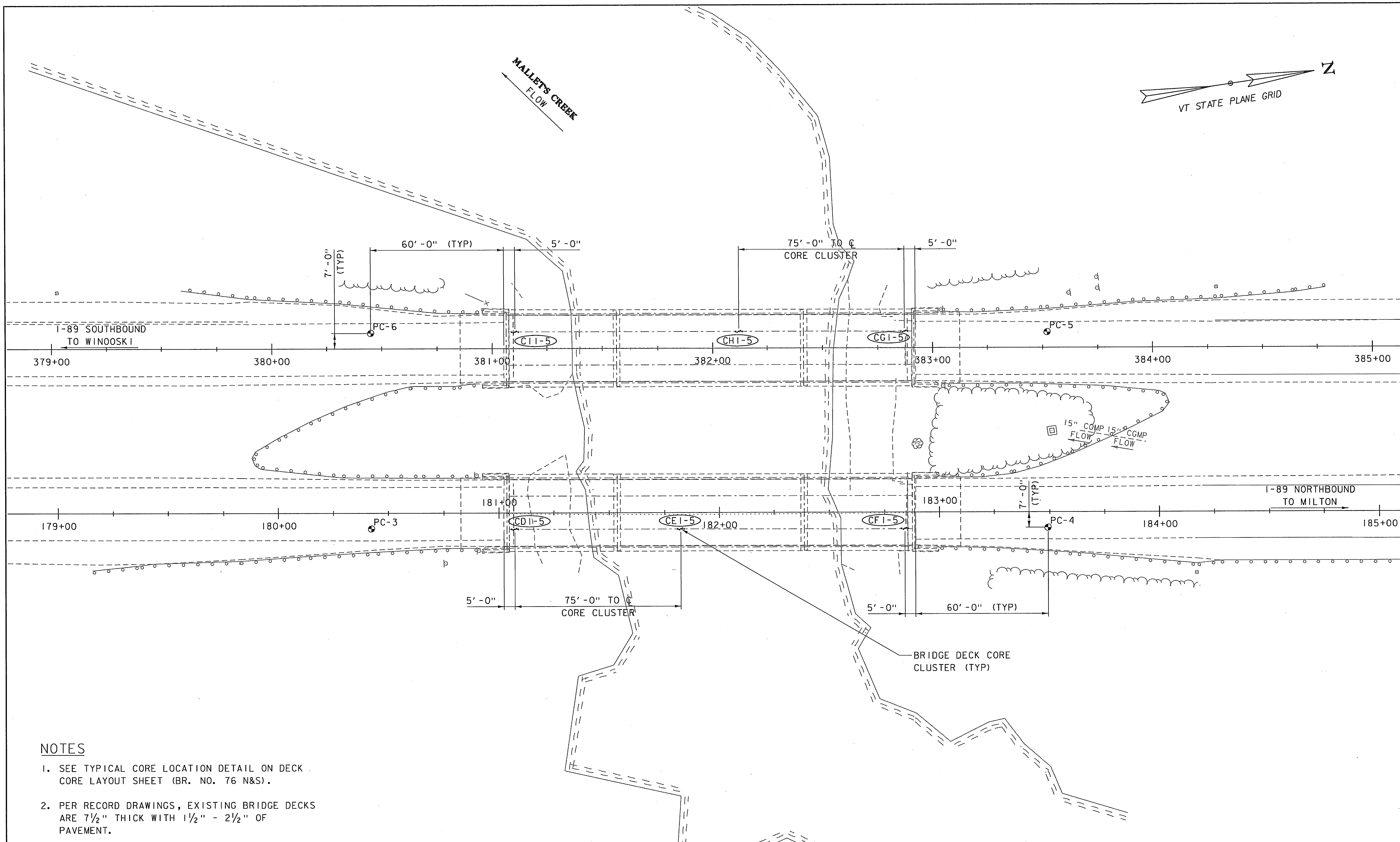
Revisions & Corrections

Drawn By: R.S.H. June 1960
Traced By: R.S.H. June 1960
Checked By: R.T.B. & R.S.H. July 1960
Recommended For Approval: [signature] Bridge Engineer Date 12/7/62
Recommended For Approval: Asst. Chief Engineer Date
Approved By: A. D. [signature] Chief Engineer Date 1/4/63

TYPICAL SECTION, PLAN VIEW, & QUANTITIES
30 FOOT ROADWAY WF BEAM BRIDGES
DESIGN LOADING - H-20-S16-44 (A.S.T.M. - A36-62T STEEL)
34-44 NON COMPOSITE, 49-99 COMPOSITE
FOR ADDITIONAL DETAILS SEE STANDARD SCB-D-62

DEPARTMENT OF HIGHWAYS
STANDARD STRUCTURES
SCB-30-62

Figure 45: Colchester IM 089 3(69) - Bridge Element Details (Page 6)



NOTES

1. SEE TYPICAL CORE LOCATION DETAIL ON DECK CORE LAYOUT SHEET (BR. NO. 76 N&S).
2. PER RECORD DRAWINGS, EXISTING BRIDGE DECKS ARE 7½" THICK WITH 1½" - 2½" OF PAVEMENT.
3. CORE VOIDS TO BE FILLED WITH APPROVED MATERIAL.
4. CD1-5 = CORE CLUSTER C, NO. 1-5.
5. PC-3 = PAVEMENT CORE NO. 3.

PROJECT NAME: COLCHESTER	
PROJECT NUMBER: IM 089-3(69)	
FILE NAME: z95a208corelocations.dgn	PLOT DATE: 9/22/2016
PROJECT LEADER: S.E. BURBANK	DRAWN BY: R.H. BARNES
DESIGNED BY: R.H. BARNES	CHECKED BY: S.E. BURBANK
CORE LAYOUT SHEET (BR. NO. 77 N&S)	SHEET 2 OF 2

vhb

VHB 57804

Figure 46: Colchester IM 089 3(69) - Bridge 77 (Page 7)

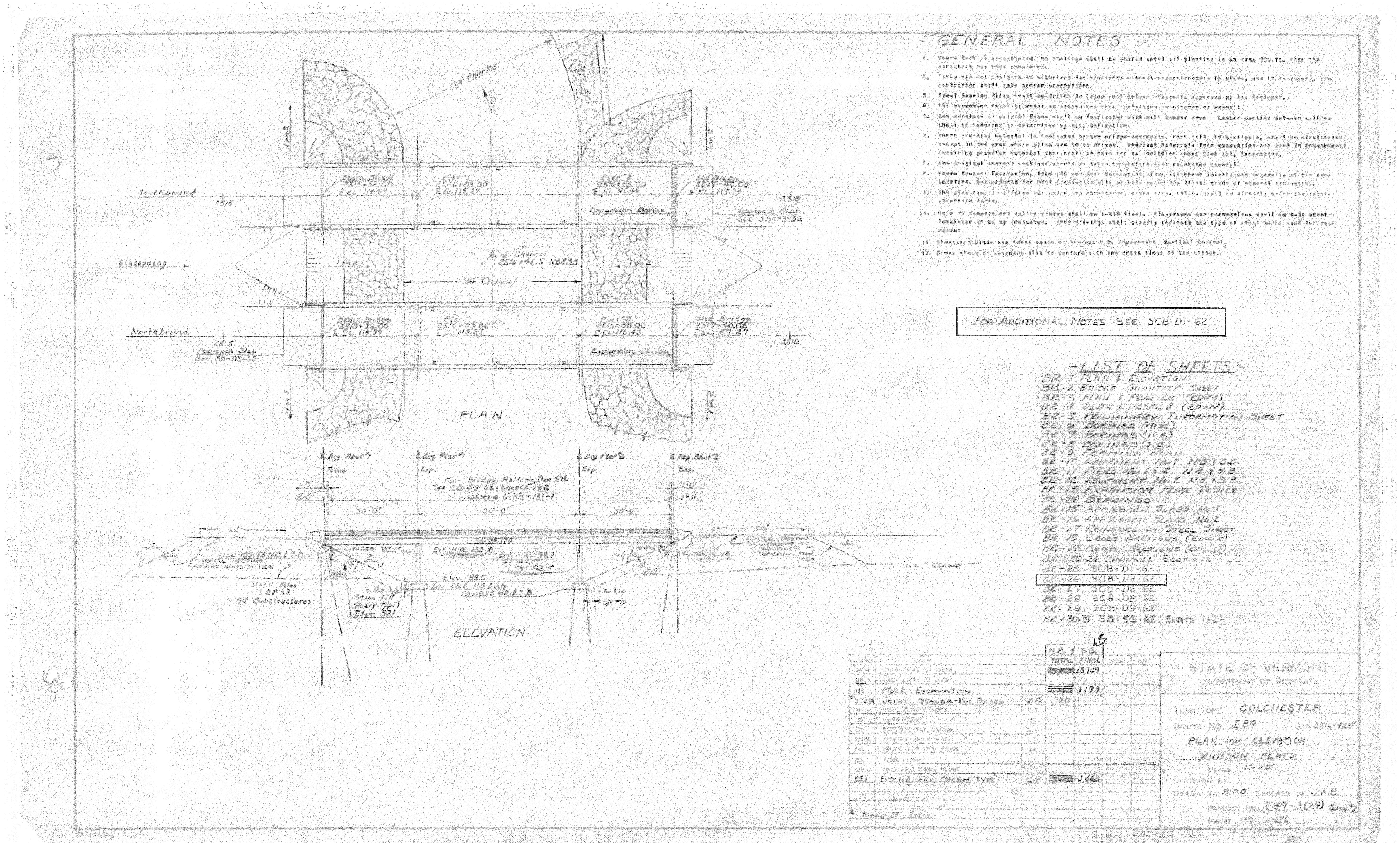


Figure 47: Colchester IM 089 3(69) - Bridge 77 (Page 8)

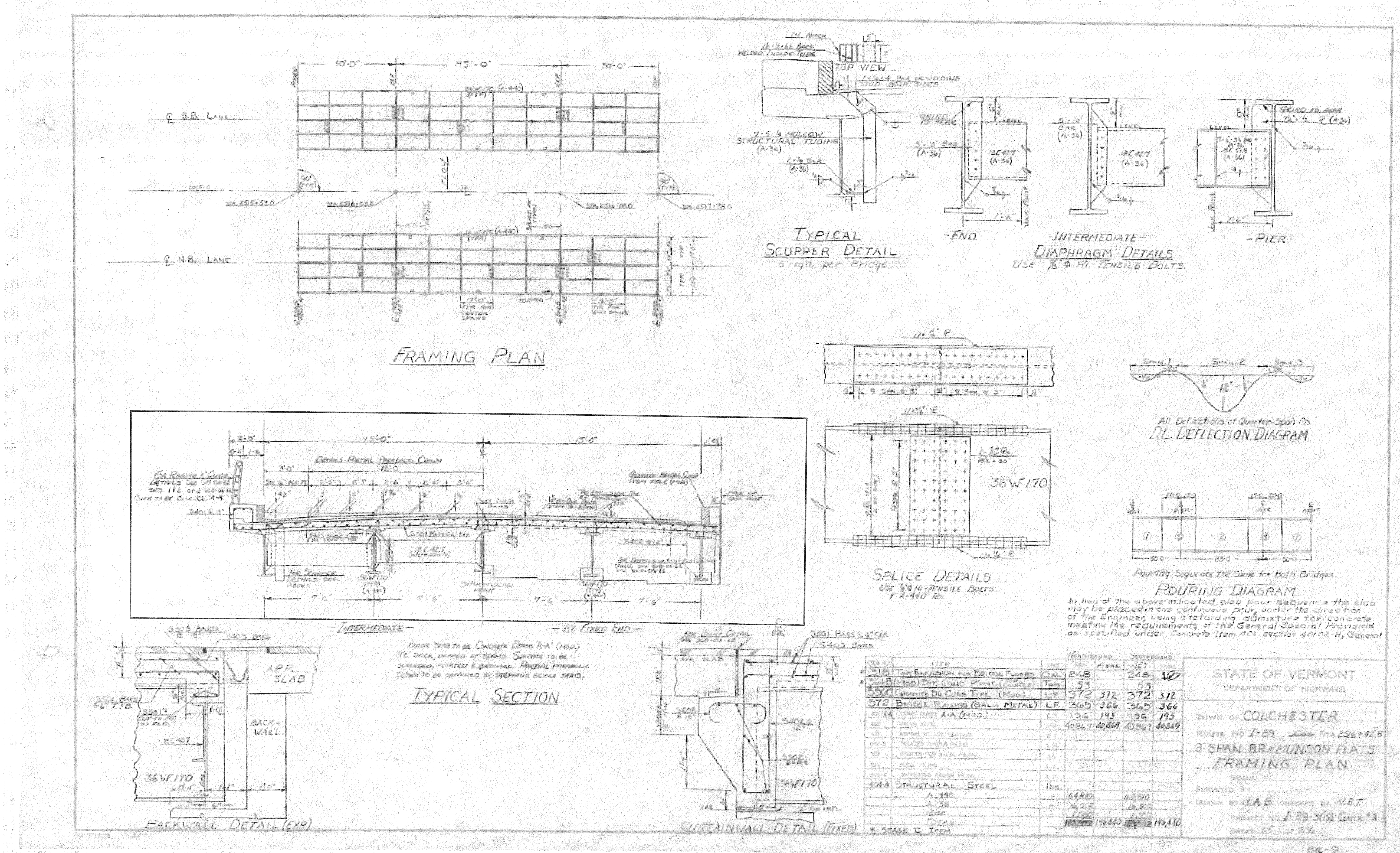


Figure 48: Colchester IM 089 3(69) - Bridge 77 (Page 9)