MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM
GEOTECHNICAL SECTION
AUGUSTA, MAINE

GEOTECHNICAL DESIGN REPORT

For the Replacement of:

ALDER BROOK BRIDGE
OVER ALDER BROOK
STATE ROUTE 182
FRANKLIN, MAINE

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Hancock County
WIN 19310.00

Soils Report No. 2012-16
Bridge No. 5728

July 31, 2012

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GEOTECHNICAL DESIGN SUMMARY

The purpose of this report is to present subsurface information and make geotechnical recommendations for the replacement of Alder Brook Bridge which carries State Route 182 over Alder Brook in Franklin, Maine. Alder Brook Bridge was built in 1955 and is a single 12.5-foot span by 7.92-foot rise by 78 foot long steel structural plate pipe arch. The proposed replacement structure will be a 12.0-foot span by 8.0-foot rise precast concrete box culvert. The proposed structure will have an overall length of approximately 74 feet. The following design recommendations are discussed in detail in Section 7.0 of this report.

Precast Concrete Box Culvert Design and Construction– The precast concrete box culvert shall be designed by the manufacturer in accordance with Special Provision 534 and AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) specifications. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The precast concrete box culvert shall be designed for all relevant strength and service limit states and load combinations. The box culvert shall be constructed with concrete inlet and outlet toe walls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing.

Precast Concrete Box Culvert Headwall Design – Concrete headwalls should be specified to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A minimum 1 foot by 1 foot concrete headwall is recommended. Precast concrete box culvert headwalls that are any larger than the nominal 1 foot by 1 foot shall be designed for all relevant strength and service limit states and load combinations. The headwalls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, creep, and temperature and shrinkage deformations of the concrete box culvert. The headwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}).

Bearing Resistance - The factored bearing resistance for the strength limit state for the box culvert on compacted fill shall not exceed 1.8 ksf, however, the service limit state will control. A factored bearing resistance of 3 ksf shall be used to control settlement when analyzing the service limit state. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$.

Settlement - In order in minimize settlements and any long term distress to the proposed structure, it is mandatory that all peat and other organic soils within the box culvert foot print be removed to the full depth from the excavation and replaced with crushed stone. The silt and clay soils shall be excavated using a smooth edged backhoe bucket to minimize disturbance to the layer. If a smooth edged bucket is not used, all disturbed soils caused by the bucket teeth should be removed by hand prior to placement of the bedding materials. The use of heavy equipment on the silt or clay layers shall be prohibited. These requirements should be noted on the Plans. With these precautions, settlement at the location of the replacement structure is anticipated to be minimal.

Scour and Riprap – The box culverts shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway and with inlet and outlet cutoff walls that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface.

Frost Protection - Any foundation placed on granular subgrade soils should be founded a minimum of 5.5 feet below finished exterior grade for frost protection.

Seismic Design Considerations – Seismic analysis is not required for buried structures, except where they cross active faults. There are no known active faults in Maine; therefore seismic analysis is not required.

Construction Considerations – The proposed box culvert will be bedded on a 2-foot thick layer of 3/4–inch crushed stone reinforced with geogrid and wrapped with geotextile fabric with a bottom elevation of approximately 101 feet. Based on the soils encountered in the boring it is likely that peat will be present at this elevation. All peat and other organic soils shall be removed to the full depth from the excavation and replaced with crushed stone.

Based on the soils encountered in the boring silt and clay soils are present beneath the peat. The silt and clay soils shall be excavated using a smooth edged backhoe bucket to minimize disturbance to the layer. If a smooth edged bucket is not used, all disturbed soils caused by the bucket teeth should be removed by hand prior to placement of the bedding materials. The use of heavy equipment on the silt or clay layers shall be prohibited.

Construction of the proposed precast concrete box culvert will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow. Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow.

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water.

1.0 INTRODUCTION

The purpose of this Geotechnical Design Report is to present geotechnical recommendations for the replacement of Alder Brook Bridge which carries State Route 182 over Alder Brook, in Franklin, Maine. A subsurface investigation has been completed at the site. The purpose of the investigation was to explore subsurface conditions at the site in order to develop geotechnical recommendations for the bridge replacement. This report presents the soils information obtained at the site during the subsurface investigation, foundation design recommendations and geotechnical design parameters for the bridge replacement.

Alder Brook Bridge was built in 1955 and consists of a single 12.5-foot span by 7.92-foot rise by 78 foot long steel structural plate pipe arch. Maine Department of Transportation (MaineDOT) Bridge Maintenance inspection report for the bridge indicates the structure is in poor but serviceable condition. The existing pipe has heavy scaling and pitting with holes at the mudline. There is moderate erosion at the downstream end of the pile. The 2011 MaineDOT Bridge Maintenance inspection report assigns the culvert a condition rating of 4 – considerable damage. The channel protection is given a rating of 5 – bank protection eroded. The structure has a scour critical rating of "6 – scour calculation/evaluation has not been made". The bridge has a Bridge Sufficiency Rating of 68.8.

The proposed replacement structure consists of a 12.0-foot span by 8.0-foot rise precast concrete box culvert. The proposed box culvert will have inlet and outlet toe walls and beveled ends which will eliminate the need for wingwalls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The overall length of the culvert will be approximately 74 feet. The existing roadway horizontal and vertical profiles will be maintained in the replacement. Staged construction with alternating one-lane traffic using traffic signals will be utilized in the replacement of the structure.

2.0 GEOLOGIC SETTING

Alder Brook Bridge is located on State Route 182 in Franklin, Maine and crosses Alder Brook approximately 0.85 miles northerly of the Alder Hill Road as shown on Sheet 1 - Location Map presented at the end of this report.

According to the Surficial Geologic Map Tunk Lake Quadrangle, Maine Open-File No. 82-5 1982 published by the Maine Geological Survey the surficial soils in the vicinity of Alder Brook Bridge site consist glacial-marine deposits (Presumpscot Formation) and till. The glacial-marine deposits are made up of mostly silt and clay with low permeability and poor drainage formed during late-glacial time. The till soils generally consist of a heterogeneous mixture of sand, silt, clay and stones and were deposited directly by glacial ice.

According to the Bedrock Geologic Map of Maine, Maine Geologic Survey, 1985, the site is underlain by Devonian alkali feldspar granite. The formation is identified as the Deblois Pluton.

3.0 SUBSURFACE INVESTIGATION

Subsurface conditions at the site were explored by drilling one (1) test boring. Test boring BB-FAB-101 was drilled within the existing roadway on the southeast side of the existing structure. The boring was drilled on February 27 and 28, 2012 by the Maine Department of Transportation (MaineDOT) drill crew. The boring location is shown on Sheet 2 - Boring Location Plan and Interpretive Subsurface Profile found at the end of this report. Details and sampling methods used, field data obtained, and soil and groundwater conditions encountered are presented in the boring log provided in Appendix A - Boring Log and on Sheet 3 - Boring Logs found end of this report.

The boring was drilled using solid stem auger and cased wash boring techniques. Soil samples were typically obtained at 5-foot intervals using Standard Penetration Test (SPT) methods. During SPT sampling, the sampler is driven 24 inches and the hammer blows for each 6 inch interval of penetration are recorded. The sum of the blows for the second and third intervals is the N-value, or standard penetration resistance. The MaineDOT drill rig is equipped with an automatic hammer to drive the split spoon. The hammer was calibrated in March of 2010 and was found to deliver approximately 40 percent more energy during driving than the standard rope and cathead system. All N-values discussed in this report are corrected values computed by applying an average energy transfer factor of 0.84 to the raw field N-values. This hammer efficiency factor, 0.84, and both the raw field N-value and the corrected N-value are shown on the boring logs. In-situ vane shear tests were made in the soft soil deposits to measure the shear strength of the strata.

The MaineDOT Geotechnical Team member selected the boring location and drilling methods, designated type and depth of sampling techniques, reviewed field logs for accuracy and identified field and laboratory testing requirements. A New England Transportation Technician Certification Program (NETTCP) Certified Subsurface Inspector logged the subsurface conditions encountered. The boring was located in the field by taping to site features after completion of the drilling program.

4.0 LABORATORY TESTING

Laboratory testing for samples obtained in the boring consisted of one (1) standard grain size analysis with natural water content, three (3) grain size analyses with hydrometer and natural water content and one (1) Atterberg Limits test. The results of soil laboratory tests are included as Appendix B - Laboratory Test Results at the end of this report. Laboratory test information is also shown on the boring logs provided in Appendix A – Boring Log and on Sheet 3 – Boring Logs at the end of this report.

5.0 SUBSURFACE CONDITIONS

Subsurface conditions encountered at test boring generally consisted of granular fill underlain by peat, silt, silty clay and sand. An interpretive subsurface profile depicting the generalized soil stratigraphy at the site is shown on Sheet 2 – Boring Location Plan and Interpretive

Subsurface Profile found at the end of this report. The boring log is provided in Appendix A – Boring Log at the end of this report. A brief summary description of the strata encountered follows:

5.1 Granular Fill

A layer of granular fill was encountered below the pavement in the boring. The layer was approximately 12.0 feet thick. The deposit generally consisted of brown, moist to wet, fine sand, with some silt.

Corrected SPT N-values obtained in the granular fill unit ranged from 6 to greater than 50 blows per foot (bpf), indicating a soil that is loose to very dense in consistency. A grain size analysis was conducted on one (1) sample from the granular fill unit resulting in the soil being classified as an A-2-4 under the AASHTO Soil Classification System and an SM under the Unified Soil Classification System. The measured natural water content of the sample tested was approximately 2 percent.

5.2 Peat

An approximately 1.5 foot thick layer of peat was encountered below the granular fill in the boring. The peat was not sampled but was visible on the augers and in the cuttings brought up by the augers.

5.3 Glacial-Marine Deposits

Silt underlain by silty clay was encountered below the peat in the boring. The silt was approximately 5.5 feet thick and consisted of olive-grey, wet, silt, with little clay, little sand and trace gravel. The silty clay was approximately 6.5 feet thick and consisted of grey, wet, silty clay, with trace sand and black staining.

One corrected SPT N-value in the silt was 6 bpf indicating that the silt is medium stiff in consistency. One grain size analysis conducted on a sample from the silt resulted in the soil being classified as an A-4 under the AASHTO Soil Classification System and a CL-ML under the Unified Soil Classification System. The measured natural water content of the sample tested was approximately 84 percent. Vane shear testing conducted within the silt showed measured undrained shear strengths ranging from approximately 290 to 357 psf while the remolded shear strength ranged from approximately 89 to 112 psf. Based on the ratio of peak to remolded shear strengths from the vane shear tests, the clayey silt was determined to have a sensitivity ranging from approximately 3.2 to 3.3 and is classified as medium sensitive.

The following table summarizes the results of the Atterberg Limits test made from a sample of the silt:

Sample No.	Soil Type	Water Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	Liquidity Index
BB-FAB-101 5D	Silt	42.3	41	22	19	1.07

Table 1 - Atterberg Limits Test Results

Interpretation of these results show that this silt with a Plasticity Index of 19 has medium plasticity and is normally consolidated as the natural water content is close to the liquid limit.

One SPT N-value in the silty clay was weigh-of-rods (WOR) indicating that the silty clay is soft in consistency. One grain size analysis conducted on a sample from the silty clay resulted in the soil being classified as an A-7-6 under the AASHTO Soil Classification System and a CL under the Unified Soil Classification System. The measured natural water content of the sample tested was approximately 42 percent.

5.4 Sand

A layer of sand was encountered below the glacial-marine deposits in the boring. The layer was approximately 2.6 feet thick. The deposit generally consisted of grey, wet, fine to coarse sand, with some silt, some gravel and trace clay.

One corrected SPT N-value obtained in the sand was 20 bpf indicating that the soil is medium dense in consistency. A grain size analysis was conducted on one (1) sample from the sand layer resulting in the soil being classified as an A-2-4 under the AASHTO Soil Classification System and an SC-SM under the Unified Soil Classification System. The measured natural water content of the sample tested was approximately 11 percent.

5.5 Termination of Exploration

The boring was terminated at a depth of approximately 28.1 feet below ground surface when the roller cone drilling tool stopped advancing (refusal) on a hard surface. This hard surface was encountered at an elevation of approximately 87.3 feet (NAVD88).

5.6 Groundwater

The measured groundwater level in the boring was approximately 7.5 feet below ground surface. The water level was measured upon completion of drilling and is indicated on the boring log in Appendix A. Note that water was introduced into the borehole during the drilling operations. It is likely that the water levels indicated on the boring log do not represent stabilized groundwater conditions. Groundwater levels will fluctuate with seasonal changes, runoff and adjacent construction activities.

6.0 FOUNDATION ALTERNATIVES

Several repair and replacement alternatives were considered for this project as follows:

- Invert lining,
- Slip lining with or without overflow culverts,
- Structure replacement with a steel pipe arch, and
- Structure replacement with a precast concrete box culvert

Invert lining and slip lining were ruled out due to the existing poor condition of the pipe and the loss of opening area compared to the existing opening. Replacement with a steel pipe arch was ruled out as constructing a pipe arch under staged construction loading can create problems with the second phase connection due to deflection of the arch. Closure of the bridge/road during construction was ruled out.

The Preliminary Design Report (PDR) for this project recommends that the replacement structure be a precast concrete box culvert using staged construction. The proposed box culvert will have inlet and outlet toe walls and beveled ends which will eliminate the need for wingwalls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. Staged construction with alternating one-way traffic using traffic signals will be utilized in the replacement of the structure.

7.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

The proposed replacement structure will consist of a 12-foot wide by 8-foot high precast concrete box culvert. The proposed box culvert will have inlet and outlet toe walls and beveled ends which will eliminate the need for wingwalls. The invert of the box culvert will be embedded approximately 2 feet into the streambed and backfilled with natural material to create a natural streambed crossing. The overall length of the culvert will be approximately 74 feet. The existing roadway horizontal and vertical profiles will be maintained in the replacement. The following sections will discuss geotechnical design recommendations for design of a precast concrete box culvert.

7.1 Precast Concrete Box Culvert Design and Construction

Precast concrete box culverts are typically detailed on the contract plans with only the basic layout and required hydraulic opening so that the Contractor may choose the appropriate structure. The manufacturer is responsible for the design of the structure including determination of the wall thickness, haunch thickness and reinforcement in accordance with Special Provision 534 Precast Concrete Arches, Box Culverts, which is included in Appendix D of this report. The loading specified for the structure should be Modified HL-93 Strength I in which the HS-20 design truck wheel loads are increased by a factor of 1.25. The designer should use Soil Type 4 as presented in the MaineDOT Bridge Design Guide (BDG) Section

3.6 to design earth loads from the soil envelope. The backfill properties are as follows: $\phi = 32$ degrees, $\gamma = 125$ pcf.

The precast concrete box shall include accommodations for toe walls at both the inlet and outlet ends to prevent undermining per MaineDOT BDG Section 8.3.1. The cutoff walls should extend below the maximum depth of scour.

The precast concrete box culverts will be supplier-designed in accordance with AASHTO LRFD Bridge Design Specifications 6th Edition 2012 (LRFD) specifications. The precast concrete box culverts shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Article 3.4.1 and LRFD Section 12. The precast concrete box culvert shall be constructed in conformance with MaineDOT BDG Section 8 and Special Provision 534.

The box culvert will be bedded on a 2-foot thick layer of 3/4–inch crushed stone (see Special Provision 203 in Appendix D) reinforced with geogrid and wrapped with geotextile fabric. The soil envelop and backfill shall consist of Standard Specification 703.19 - Granular Borrow Material for Underwater Backfill with a maximum particle size of 4 inches. The crushed stone bedding should be placed in 12 inch maximum thick lifts and compacted with a minimum of four passes of a large walk behind compactor. The granular borrow backfill should be placed in lifts of 6 to 8 inches thick loose measure and compacted to the manufacturer's specifications. In no case shall the backfill soil be compacted less than 92 percent of the AASHTO T-180 maximum dry density.

7.2 Precast Concrete Box Culvert Headwall Design

Concrete headwalls should be included in the culvert design to retain riprap slopes and prevent riprap from dropping or eroding into the waterway. A nominal 1 foot by 1 foot concrete headwall is recommended.

Larger precast or cast-in-place concrete box culvert headwalls are essentially retaining walls and shall be designed for all relevant strength and service limit states and load combinations specified in LRFD Articles 3.4.1, 11.5.5 and 11.6. The head walls shall be designed to resist and/or absorb lateral earth loads, vehicular loads, creep, and temperature and shrinkage deformations of the concrete box culvert. The headwalls shall be designed considering a live load surcharge equal to a uniform horizontal earth pressure due to an equivalent height of soil (h_{eq}) taken from Table 2 below:

Wall Height (feet)	h_{eq} (feet)	
	Distance from wall pressure surface to edge of traffic = 0 feet	Distance from wall pressure surface to edge of traffic ≥ 1 foot
5	5.0	2.0
10	3.5	2.0
≥20	2.0	2.0

Table 2 – Equivalent Height of Soil for Vehicular Loading on Retaining Walls

Culvert headwall sections that are fixed to the box culverts to resist movement should be designed using an at-rest earth pressure coefficient, K_o, of 0.5. Headwall sections that are independent of the box culvert should be designed using the Rankine active earth pressure coefficient, K_a, of 0.31 assuming a level back slope. The active earth pressure coefficient may change if the back slope conditions are different. See Appendix C - Calculations for supporting documentation.

Footings for any headwall or wingwall constructed independently of the box culvert should be placed no less than 2.0 feet below the maximum anticipated scour depth.

7.3 Bearing Resistance

The factored bearing resistance at the strength limit state for the box culvert on compacted fill shall not exceed 1.8 kips per square foot (ksf), however, the service limit state bearing resistance will govern. A factored bearing resistance of 3 ksf shall be used to control settlement when analyzing the service limit state as allowed in LRFD C10.6.2.6.1. In no instance shall the bearing stress exceed the nominal resistance of the structural concrete which may be taken as $0.3f'_c$. See Appendix C - Calculations for supporting documentation.

7.4 Scour and Riprap

The box culverts shall be fitted with integral concrete headwalls to retain riprap slopes and prevent riprap from dropping or eroding into the waterway and with inlet and outlet cutoff walls that extend below the maximum depth of scour. The slopes shall be armored with a 3-foot thick layer of riprap conforming to MaineDOT Supplemental Specification Section 703.26 Plain and Hand Laid Riprap. The riprap shall be underlain by a Class 1 erosion control geotextile and a 1-foot layer of bedding material conforming to MaineDOT Standard Specification 703.19 Granular Borrow Material for Underwater Backfill. The toe of the riprap sections shall be constructed 1 foot below the streambed elevation. The riprap slopes should also be constructed in accordance with MaineDOT Supplemental Specification Section 610 – Stone Fill, Riprap, Stone Blanket and Stone Ditch Protection and shall be constructed no steeper than a maximum 1.75H:1V extending from the edge of the roadway down to the existing ground surface.

7.5 Settlement

Based on the soils encountered in the boring it is likely that peat and/or soft silt and clay will be present at box foundation or granular mat bottom elevation. In order in minimize settlements and any long term distress to the proposed structure, it is mandatory that all peat and other organic soils within the box culvert foot print be removed to the full depth from the excavation and replaced with crushed stone. The silt and clay soils shall be excavated using a smooth edged backhoe bucket to minimize disturbance to the layer. If a smooth edged bucket is not used, all disturbed soils caused by the bucket teeth should be removed by hand prior to placement of the bedding materials. The use of heavy equipment on the silt or clay layers shall be prohibited. These requirements should be noted in the General Notes on the final plans.

The existing roadway vertical profile will be maintained in the structure replacement. Settlement at the location of the replacement structure is anticipated to be minimal. The installation of the proposed box culvert will result in a net unloading of the site soils at the structure location. No settlement issues are anticipated at the site.

7.6 Frost Protection

Any foundation placed on granular subgrade soils should be designed with an appropriate embedment for frost protection. According to the Modberg Software by the US Army Cold Regions Research and Engineering Laboratory, the site has an air design-freezing index of approximately 1256 F-degree days. Considering the site soils and natural water contents determined in the laboratory, this correlates to a frost depth of approximately 5.5 feet. Therefore, any foundations placed on granular soils should be founded a minimum of 5.5 feet below finished exterior grade for frost protection. See Appendix C- Calculations at the end of this report for supporting documentation.

7.7 Seismic Design Considerations

In conformance with LRFD Article 3.10.1, seismic analysis is not required for buried structures, except where they cross active faults. There are no known active faults in Maine; therefore seismic analysis is not required.

7.8 Construction Considerations

The proposed box culvert will be bedded on a 2-foot thick layer of 3/4–inch crushed stone reinforced with geogrid and wrapped with geotextile fabric with a bottom elevation of approximately 101 feet. Based on the soils encountered in the boring it is likely that peat will be present at this elevation. All peat and other organic soils with in the box culvert footprint shall be removed to the full depth from the excavation and replaced with crushed stone.

Based on the soils encountered in the boring silt and clay soils are present beneath the peat. The silt and clay soils shall be excavated using a smooth edged backhoe bucket to minimize

disturbance to the layer. If a smooth edged bucket is not used, all disturbed soils caused by the bucket teeth should be removed by hand prior to placement of the bedding materials. The use of heavy equipment on the silt or clay layers shall be prohibited.

Construction of the proposed precast concrete box culverts will require soil excavation. Earth support systems will be required. The fill and native soils at the site will be susceptible to disturbance and rutting as a result of exposure to water and construction traffic. All subgrade surfaces should be protected from any unnecessary construction traffic. If disturbance and rutting occur, the Contractor shall remove and replace disturbed areas with compacted gravel borrow. Any cobbles or boulder encountered in excess of 6 inches shall be removed and replaced with compacted gravel borrow.

The Contractor shall control groundwater and surface water infiltration using temporary ditches, sumps, granular drainage blankets, stone ditch protection or hand-laid riprap with geotextile underlayment to divert groundwater and surface water.

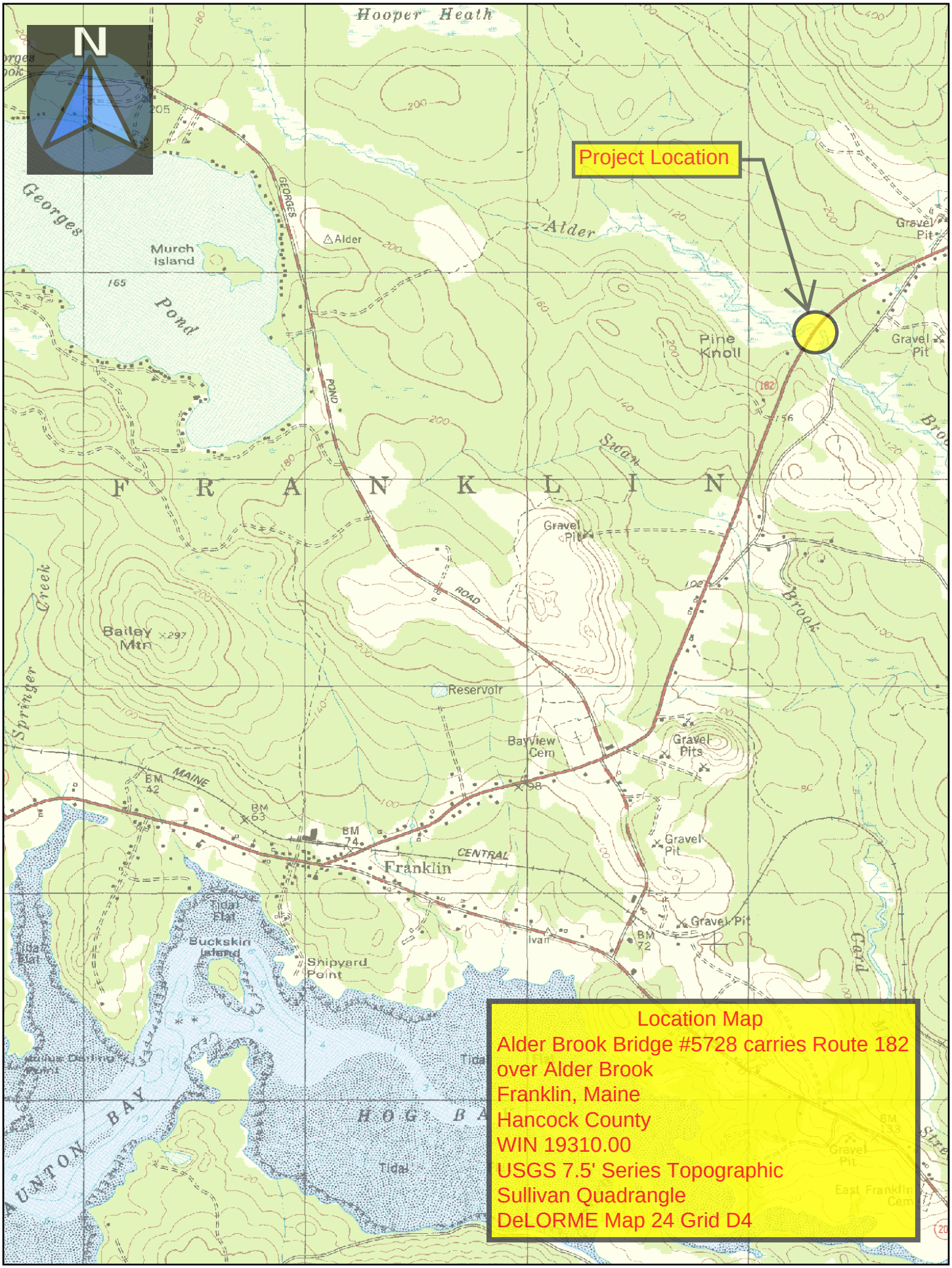
8.0 CLOSURE

This report has been prepared for the use of the MaineDOT Bridge Program for specific application to the proposed replacement of Alder Brook Bridge in Franklin, Maine in accordance with generally accepted geotechnical and foundation engineering practices. No other intended use or warranty is expressed or implied.

In the event that any changes in the nature, design, or location of the proposed project are planned, this report should be reviewed by a geotechnical engineer to assess the appropriateness of the conclusions and recommendations and to modify the recommendations as appropriate to reflect the changes in design. Further, the analyses and recommendations are based in part upon limited soil explorations at discrete locations completed at the site. If variations from the conditions encountered during the investigation appear evident during construction, it may also become necessary to re-evaluate the recommendations made in this report.

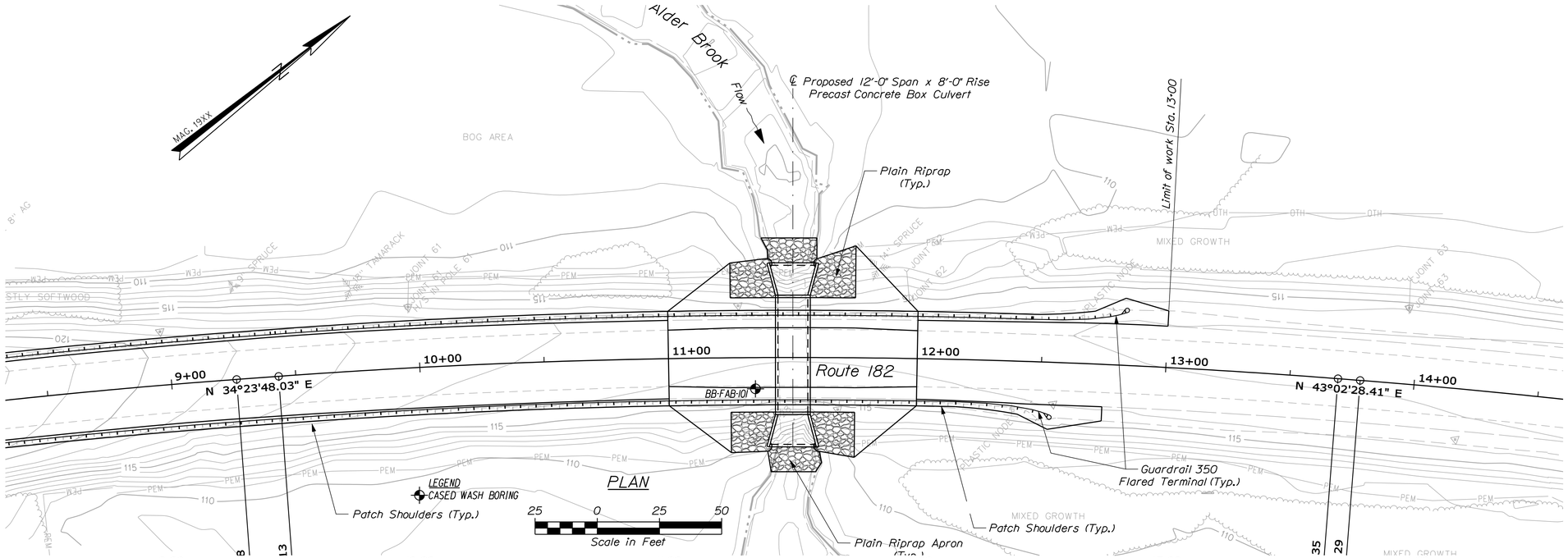
It is also recommend that the geotechnical designer be provided the opportunity for a general review of the final design plans and specifications in order to verify that the earthwork and foundation recommendations have been properly interpreted and implemented in the design.

Sheets



Map Scale 1:24000

The Maine Department of Transportation provides this publication for information only. Reliance upon this information is at user risk. It is subject to revision and may be incomplete depending upon changing conditions. The Department assumes no liability if injuries or damages result from this information. This map is not intended to support emergency dispatch. Road names used on this map may not match official road names.



LEGEND

Boring No. Offset, if shown
Pavement Thickness if applicable
Strata Interface
Boring
RQD: Rock Quality Designation for Rock Core Sample
BOE: Bottom Of Exploration
Refusal

Note: This generalized interpretive soil profile is intended to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and have been developed by interpretations of widely spaced explorations and samples. Actual soil transitions may vary and are probably more erratic. For more specific information refer to the exploration logs.

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

019310.00

PIN 19310.00

BRIDGE PLANS

BRIDGE NO. 5728

	BY	DATE
PROJ. MANAGER	S. BODGE	
DESIGN-DETAILED	K.MAGUIRE	T.WHITE	JUL 2012
CHECKED-REVIEWED		
DESIGN2-DETAILED2		
DESIGN3-DETAILED3		
REVISIONS 1		
REVISIONS 2		
REVISIONS 3		
REVISIONS 4		
FIELD CHANGES		

SIGNATURE

P.E. NUMBER

DATE

ALDER BROOK BRIDGE
ALDER BROOK
FRANKLIN HANCOCK COUNTY

BORING LOCATION PLAN &
INTERPRETIVE SUBSURFACE PROFILE

SHEET NUMBER
2
OF 3

Filename: ...\GEOTECH\MSTA\006_BLP&ISP1.dgn Division: GEOTECH Username: terry.white Date:7/31/2012

Filename: ...\msta\007_BORING LOGS1.dgn Division: GEOTECH Username: terry.white Date:7/31/2012

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alder Brook Bridge #5728 carries Route 182 over Alder Brook
Location: Franklin, Maine

Boring No.: BB-FAB-101
WIN: 19310.00

Driller:	MaineDOT	Elevation (ft.)	115.4	Auger ID/OD:	5" Dia Solid Stem
Operator:	Giguere/Giles	Datum:	NAVD88	Sampler:	Standard Split Spoon
Logged By:	B. Wilder	Rig Type:	CME 45C	Hammer Wt./Fall:	140#/30"
Date Start/Finish:	2/27/12-2/28/12	Drilling Method:	Cased Wash Boring	Core Barrel:	N/A
Boring Location:	11+34.9, 12.5 ft Rt.	Casing ID/OD:	NW	Water Level*:	7.5 ft bgs.
Hammer Efficiency Factor: 0.84		Hammer Type:	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test. PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WOTP = Weight of one person
S_U = Insitu Field Vane Shear Strength (psf)
T_V = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw Field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60)*N-uncorrected
$S_{U(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample Information: Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	114.98		5" Pavement	
										0.42	
	10	12/9	1.50 - 2.50	9/50	---					Brown, moist, dense, fine SAND, some silt. (Fill).	
5	20	24/16	5.00 - 7.00	4/8/4/4	12	17				Brown, moist, medium dense, fine SAND, some silt. (Fill).	GM261876 A-2-4, SM WC=11.7%
10	30	24/1	10.00 - 12.00	WOH/2/2/2	4	6				Similar to above, except wet, loose. (Fill).	
								103.40		12.00	
										PEAT, on auger.	
								101.90		13.50	
15	40	24/18	15.00 - 17.00	2/2/2/2	4	6	10			Olive-grey, wet, medium stiff, SILT, little clay, little sand, trace gravel. (Glaciomarine Deposit).	GM261877 A-4, CL-ML WC=84.1%
							9				
							10				
							9				
							11	96.40		19.00	
20							OPEN HOLE				
	SD V1	24/20	21.00 - 23.00	WOR/WOR/WOR/WOR Su=357/112 psf	---					Grey, wet, soft, silty CLAY, trace sand, with black staining. (Glaciomarine Deposit). 55x110 mm vane raw torque readings: V1: 8.0/2.5 ft-lbs V2: 6.5/2.0 ft-lbs	GM261878 A-7-6, CL WC=42.3% LL=41 PL=22 PI=19
			21.63 - 22.00								
	V2		22.00 - 22.63	Su=290/89 psf							
			22.63 - 23.00								
25	60 MV	24/15	25.00 - 27.00	8/6/8/6 Would not push	14	20		89.90		Grey, wet, medium dense, fine to coarse SAND, some silt, some gravel, trace clay. Failed 55x110 mm vane attempt. 25.50	GM261879 W-2-4, SC-SM WC=10.8%
			25.63 - 25.63								
								87.30		28.10	
30										Bottom of Exploration at 28.10 feet below ground surface. ROLLER CONE REFUSAL, very hard.	
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil typest transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Boring No.: BB-FAB-101

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION

019310.00

PIN 19310.00

BRIDGE NO. 5728

BRIDGE PLANS

	BY	DATE
PROJ. MANAGER	S. BODGE	
DESIGN-DETAILED	K.MAGUIRE	
CHECKED-REVIEWED	T.WHITE	JUL 2012
DESIGN2-DETAILED2	-----	-----
DESIGN3-DETAILED3	-----	-----
REVISIONS 1	-----	-----
REVISIONS 2	-----	-----
REVISIONS 3	-----	-----
REVISIONS 4	-----	-----
FIELD CHANGES	-----	-----

SIGNATURE

P.E. NUMBER

DATE

ALDER BROOK BRIDGE
ALDER BROOK
FRANKLIN HANCOCK COUNTY

BORING LOGS

SHEET NUMBER
3
OF 3

Appendix A

Boring Log

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve size)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve size)	CLEAN GRAVELS (little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly-graded gravels, gravel sand mixtures, little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.
			GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve size)	CLEAN SANDS (little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly-graded sands, gravelly sand, little or no fines.
		SANDS WITH FINES (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve size)	SILTS AND CLAYS (liquid limit less than 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	SILTS AND CLAYS (liquid limit greater than 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.

Desired Soil Observations: (in this order)

Color (Munsell color chart)
Moisture (dry, damp, moist, wet, saturated)
Density/Consistency (from above right hand side)
Name (sand, silty sand, clay, etc., including portions - trace, little, etc.)
Gradation (well-graded, poorly-graded, uniform, etc.)
Plasticity (non-plastic, slightly plastic, moderately plastic, highly plastic)
Structure (layering, fractures, cracks, etc.)
Bonding (well, moderately, loosely, etc., if applicable)
Cementation (weak, moderate, or strong, if applicable, ASTM D 2488)
Geologic Origin (till, marine clay, alluvium, etc.)
Unified Soil Classification Designation
Groundwater level

Maine Department of Transportation
Geotechnical Section
Key to Soil and Rock Descriptions and Terms
Field Identification Information

TERMS DESCRIBING DENSITY/CONSISTENCY

Coarse-grained soils (more than half of material is larger than No. 200 sieve): Includes (1) clean gravels; (2) silty or clayey gravels; and (3) silty, clayey or gravelly sands. Consistency is rated according to standard penetration resistance.

Modified Burmister System

Descriptive Term	Portion of Total
trace	0% - 10%
little	11% - 20%
some	21% - 35%
adjective (e.g. sandy, clayey)	36% - 50%

Density of Cohesionless Soils	Standard Penetration Resistance N-Value (blows per foot)
Very loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	> 50

Fine-grained soils (more than half of material is smaller than No. 200 sieve): Includes (1) inorganic and organic silts and clays; (2) gravelly, sandy or silty clays; and (3) clayey silts. Consistency is rated according to shear strength as indicated.

Consistency of Cohesive soils	SPT N-Value blows per foot	Approximate Undrained Shear Strength (psf)	Field Guidelines
Very Soft	WOH, WOR, WOP, <2	0 - 250	Fist easily Penetrates
Soft	2 - 4	250 - 500	Thumb easily penetrates
Medium Stiff	5 - 8	500 - 1000	Thumb penetrates with moderate effort
Stiff	9 - 15	1000 - 2000	Indented by thumb with great effort
Very Stiff	16 - 30	2000 - 4000	Indented by thumbnai
Hard	>30	over 4000	Indented by thumbnail with difficulty

Rock Quality Designation (RQD):

$$RQD = \frac{\text{sum of the lengths of intact pieces of core* > 100 mm}}{\text{length of core advance}}$$

*Minimum NQ rock core (1.88 in. OD of core)

Correlation of RQD to Rock Mass Quality

Rock Mass Quality	RQD
Very Poor	<25%
Poor	26% - 50%
Fair	51% - 75%
Good	76% - 90%
Excellent	91% - 100%

Desired Rock Observations: (in this order)

Color (Munsell color chart)
Texture (aphanitic, fine-grained, etc.)
Lithology (igneous, sedimentary, metamorphic, etc.)
Hardness (very hard, hard, mod. hard, etc.)
Weathering (fresh, very slight, slight, moderate, mod. severe, severe, etc.)
Geologic discontinuities/jointing:
- -dip (horiz - 0-5, low angle - 5-35, mod. dipping - 35-55, steep - 55-85, vertical - 85-90)
- -spacing (very close - <5 cm, close - 5-30 cm, mod. close 30-100 cm, wide - 1-3 m, very wide >3 m)
- -tightness (tight, open or healed)
- -infilling (grain size, color, etc.)

Formation (Waterville, Ellsworth, Cape Elizabeth, etc.)
RQD and correlation to rock mass quality (very poor, poor, etc.)
ref: AASHTO Standard Specification for Highway Bridges 17th Ed. Table 4.4.8.1.2A
Recovery

Sample Container Labeling Requirements:

PIN
Bridge Name / Town
Boring Number
Sample Number
Sample Depth
Blow Counts
Sample Recovery
Date
Personnel Initials

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alder Brook Bridge #5728 carries Route 182 over Alder Brook
Location: Franklin, Maine

Boring No.: BB-FAB-101
WIN: 19310.00

Driller:	MaineDOT	**Elevation (ft.)**	115.4	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/27/12-2/28/12	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+34.9, 12.5 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	7.5 ft bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
MU = Unsuccessful Thin Wall Tube Sample attempt
V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
0							SSA	114.98		5" Pavement	
										0.42	
	1D	12/9	1.50 - 2.50	9/50	---					Brown, moist, dense, fine SAND, some silt, (Fill).	
5	2D	24/16	5.00 - 7.00	4/8/4/4	12	17				Brown, moist, medium dense, fine SAND, some silt, (Fill).	G#261876 A-2-4, SM WC=1.7%
10	3D	24/1	10.00 - 12.00	WOH/2/2/2	4	6				Similar to above, except wet, loose, (Fill).	
								103.40		12.00	
										PEAT, on auger.	
								101.90		13.50	
15	4D	24/18	15.00 - 17.00	2/2/2/2	4	6	10			Olive-grey, wet, medium stiff, SILT, little clay, little sand, trace gravel. (Glaciomarine Deposit).	G#261877 A-4, CL-ML WC=84.1%
							9				
							10				
							9				
							11	96.40		19.00	
20							OPEN HOLE				
	5D	24/20	21.00 - 23.00	WOR/WOR/WOR/ WOR	---					Grey, wet, soft, silty CLAY, trace sand, with black staining, (Glaciomarine Deposit).	G#261878 A-7-6, CL WC=42.3% LL=41 PL=22 PI=19
	V1		21.63 - 22.00	Su=357/112 psf						55x110 mm vane raw torque readings:	
	V2		22.63 - 23.00	Su=290/89 psf						V1: 8.0/2.5 ft-lbs	
										V2: 6.5/2.0 ft-lbs	
25											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Maine Department of Transportation

Soil/Rock Exploration Log
US CUSTOMARY UNITS

Project: Alder Brook Bridge #5728 carries Route 182 over Alder Brook
Location: Franklin, Maine

Boring No.: BB-FAB-101
WIN: 19310.00

Driller:	MaineDOT	**Elevation (ft.)**	115.4	**Auger ID/OD:**	5" Dia Solid Stem
Operator:	Giguere/Giles	**Datum:**	NAVD88	**Sampler:**	Standard Split Spoon
Logged By:	B. Wilder	**Rig Type:**	CME 45C	**Hammer Wt./Fall:**	140#/30"
Date Start/Finish:	2/27/12-2/28/12	**Drilling Method:**	Cased Wash Boring	**Core Barrel:**	N/A
Boring Location:	11+34.9, 12.5 ft Rt.	**Casing ID/OD:**	NW	**Water Level*:**	7.5 ft bgs.
Hammer Efficiency Factor:	0.84	**Hammer Type:**	Automatic ☒ Hydraulic ☐ Rope & Cathead ☐		

Definitions:
D = Split Spoon Sample
MD = Unsuccessful Split Spoon Sample attempt
U = Thin Wall Tube Sample
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V = Insitu Vane Shear Test, PP = Pocket Penetrometer
MV = Unsuccessful Insitu Vane Shear Test attempt
R = Rock Core Sample
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RC = Roller Cone
WOH = weight of 140lb. hammer
WOR/C = weight of rods or casing
WO1P = Weight of one person
S_u = Insitu Field Vane Shear Strength (psf)
T_v = Pocket Torvane Shear Strength (psf)
q_p = Unconfined Compressive Strength (ksf)
N-uncorrected = Raw field SPT N-value
Hammer Efficiency Factor = Annual Calibration Value
N_{60} = SPT N-uncorrected corrected for hammer efficiency
N_{60} = (Hammer Efficiency Factor/60%)*N-uncorrected
$S_{u(lab)}$ = Lab Vane Shear Strength (psf)
WC = water content, percent
LL = Liquid Limit
PL = Plastic Limit
PI = Plasticity Index
G = Grain Size Analysis
C = Consolidation Test

Depth (ft.)	Sample No.	Pen./Rec. (in.)	Sample Depth (ft.)	Blows (/6 in.) Shear Strength (psf) or RQD (%)	N-uncorrected	N_{60}	Casing Blows	Elevation (ft.)	Graphic Log	Visual Description and Remarks	Laboratory Testing Results/ AASHTO and Unified Class.
25	6D MV	24/15	25.00 - 27.00 25.63 - 25.63	8/6/8/6 Would not push	14	20		89.90		25.50 Grey, wet, medium dense, fine to coarse SAND, some silt, some gravel, trace clay. Failed 55x110 mm vane attempt.	G#261879 A-2-4, SC-SM WC=10.8%
								87.30		28.10 **Bottom of Exploration at 28.10 feet below ground surface.** ROLLER CONE REFUSAL, very hard.	
30											
35											
40											
45											
50											

Remarks:

Stratification lines represent approximate boundaries between soil types; transitions may be gradual.

* Water level readings have been made at times and under conditions stated. Groundwater fluctuations may occur due to conditions other than those present at the time measurements were made.

Appendix B

Laboratory Test Results

State of Maine - Department of Transportation

Laboratory Testing Summary Sheet

Town(s): Franklin Work Number: 19310.00

Boring & Sample Identification Number	Station (Feet)	Offset (Feet)	Depth (Feet)	Reference Number	G.S.D.C. Sheet	W.C. %	L.L.	P.I.	Classification		
									Unified	AASHTO	Frost
BB-FAB-101, 2D	11+34.9	12.5 Rt.	5.0-7.0	261876	1	1.7			SM	A-2-4	II
BB-FAB-101, 4D	11+34.9	12.5 Rt.	15.0-17.0	261877	1	84.1			CL-ML	A-4	IV
BB-FAB-101, 5D	11+34.9	12.5 Rt.	21.0-23.0	261878	1	42.3	41	19	CL	A-7-6	III
BB-FAB-101, 6D	11+34.9	12.5 Rt.	25.5-27.0	261879	1	10.8			SC-SM	A-2-4	II

Classification of these soil samples is in accordance with AASHTO Classification System M-145-40. This classification is followed by the "Frost Susceptibility Rating" from zero (non-frost susceptible) to Class IV (highly frost susceptible). The "Frost Susceptibility Rating" is based upon the MaineDOT and Corps of Engineers Classification Systems.

GSDC = Grain Size Distribution Curve as determined by AASHTO T 88-93 (1996) and/or ASTM D 422-63 (Reapproved 1998)

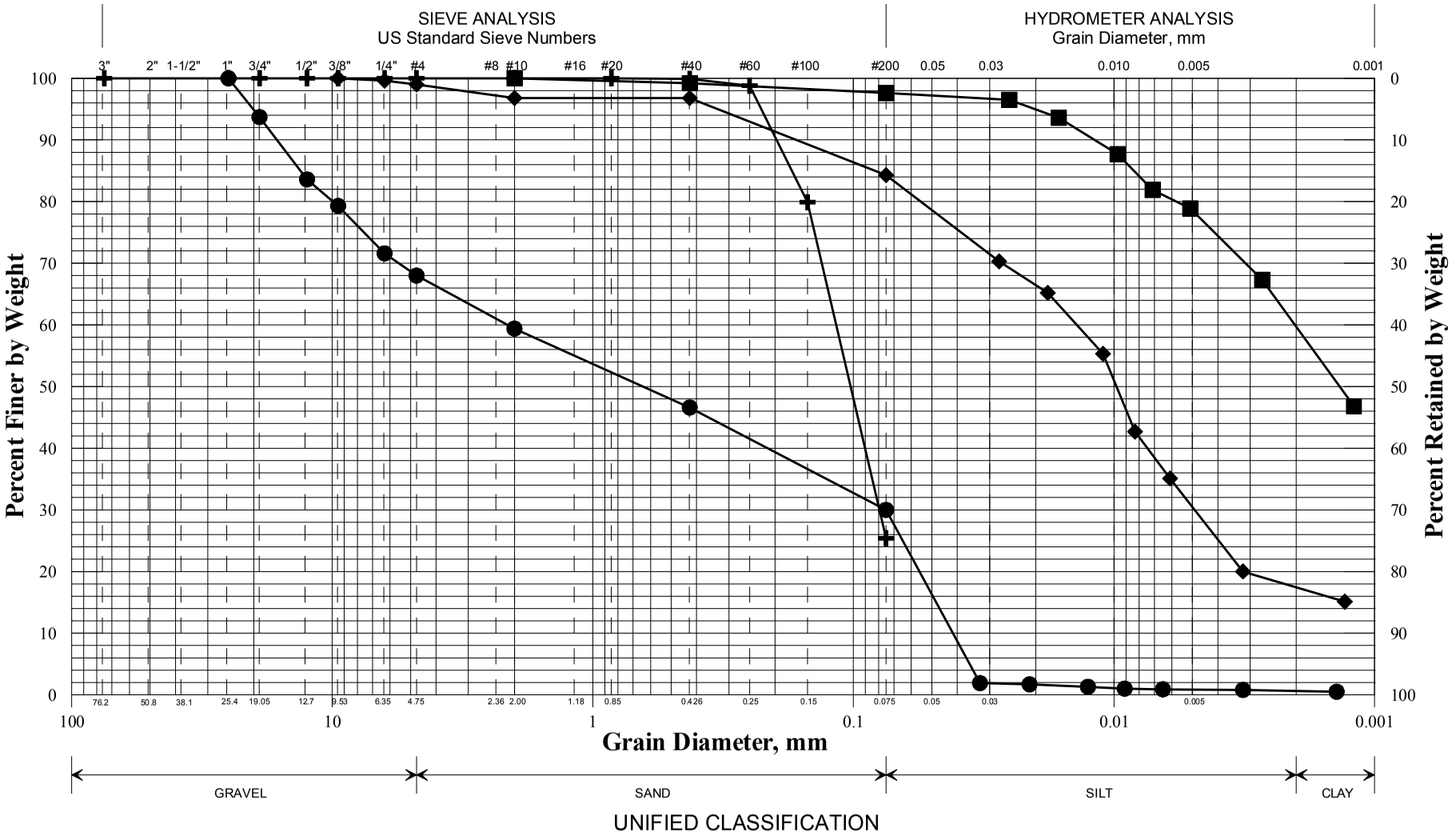
WC = water content as determined by AASHTO T 265-93 and/or ASTM D 2216-98

LL = Liquid limit as determined by AASHTO T 89-96 and/or ASTM D 4318-98 NP = Non Plastic

PI = Plasticity Index as determined by AASHTO 90-96 and/or ASTM D4318-98

State of Maine Department of Transportation

GRAIN SIZE DISTRIBUTION CURVE



	Boring/Sample No.	Station	Offset, ft	Depth, ft	Description	W, %	LL	PL	PI
✚	BB-FAB-101/2D	11+34.9	12.5 RT	5.0-7.0	SAND, some silt.	1.7			
◆	BB-FAB-101/4D	11+34.9	12.5 RT	15.0-17.0	SILT, little clay, little sand, trace gravel.	84.1			
■	BB-FAB-101/5D	11+34.9	12.5 RT	21.0-23.0	Silty CLAY, trace sand.	42.3	41	22	19
●	BB-FAB-101/6D	11+39.9	12.5 RT	25.0-27.0	SAND, some gravel, some silt, trace clay.	10.8			
▲									
✖									

WIN
019310.00
Town
Franklin
Reported by/Date
WHITE, TERRY A 4/13/2012

Appendix C

Calculations

LIQUIDITY INDEX (LI):

$$\text{Liquidity Index} = \frac{\text{natural water content - Plastic Limit}}{\text{Liquid Limit - Plastic Limit}}$$

wc is close to LL	Soil is normally consolidated
wc is close to PL	Soil is some-to-heavily over consolidated
wc is intermediate	Soil is over consolidated
wc is greater than LL	Soil is on the verge of being a viscous liquid when remolded

Sample	Soil	WC	LL	PL	PI	LI	Interpretation
BB-FAB-101 5D	Silt	42.3	41	22	19	1.07	Medium plasticity, normally consolidated

At-Rest and Active Earth Pressure:

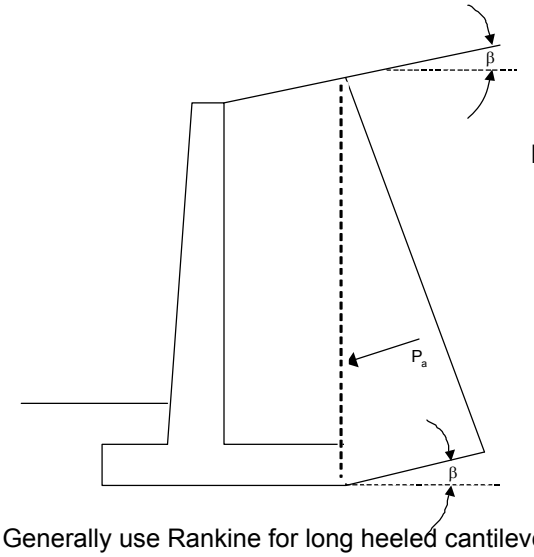
At-Rest Lateral Earth Pressure
from LRFD Article 3.11.5.2 pg 3-71

Effective friction angle of soil $\phi_f := 30 \cdot deg$

$K_o := 1 - \sin(\phi_f)$ $K_o = 0.5$

Active Earth Pressure - Rankine Theory
from MaineDOT Bridge Design Guide Section 3.6.5.2 pg 3-7

Soil Type 4 Properties from MaineDOT Bridge Design Guide (BDG)



unit weight: $\gamma_{type4} := 125 \cdot pcf$

Internal Friction Angle: $\phi_{type4} := 32 \cdot deg$

Cohesion: $c_{sand} := 0 \cdot psf$

Generally use Rankine for long heeled cantilever walls where the failure surface is un interrupted by the top of the wall system. The earth pressure is applied to a plane extending vertically up from the heel of the wall base and the weight of the soil on the inside of the vertical plane is considered as part of the wall weight. The failure sliding surface is not restricted by the top of the wall or the backface of the wall.

For cantilever walls with sloped backfill surface:

β = Angel of fill slope to the horizontal

$\beta := 0 \cdot deg$ assume horizontal backfill surface

$$K_{a\_rankine\_slope} := \frac{\cos(\beta) - \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}}{\cos(\beta) + \sqrt{\cos(\beta)^2 - \cos(\phi_{type4})^2}} \qquad K_{a\_rankine\_slope} = 0.31$$

Pa is oriented at an angle of β to the vertical plane.

Bearing Resistance - Native Soils:

Part 1 - Service Limit State

Nominal and factored Bearing Resistance - box culvert on native silt, ALL PEAT REMOVED

Presumptive Bearing Resistance for Service Limit State ONLY

Reference: AASHTO LRFD Bridge Design Specifications 6th Edition 2012
Table C10.6.2.6.1-1 Presumptive Bearing Resistances for Spread Footings at the Service Limit State Modified after US Department of Navy (1982)

Type of Bearing Material: Inorganic silt (ML)

Based on N-value of 6 - Silt is medium stiff

Consistency In Place: medium stiff

Bearing Resistance: Ordinary Range 2 to 6 (ksf)

Recommended Value of Use: 3 ksf

$$tsf := g \cdot \left(\frac{ton}{ft^2}\right)$$

Recommended Value: $3 \cdot ksf = 1.5 \cdot tsf$

Therefore: $q_{nom} := 1.5 \cdot tsf$

Resistance factor at the **service limit state** = 1.0 (LRFD Article 10.5.5.1)

$q_{factored\_bc} := 1.5 \cdot tsf$ or $q_{factored\_bc} = 3 \cdot ksf$

Note: This bearing resistance is settlement limited (1 inch) and applies only at the service limit state.

Part 2 - Strength Limit State

Nominal and factored Bearing Resistance - box culvert on native silt - ALL PEAT REMOVED
Reference: Foundation Engineering and Design by JE Bowles Fifth Edition

Assumptions:
1. The box culvert will be founded at ~ Elev 103 $D_{box} := 2.0 \cdot ft$
2. Assumed parameters for silt:
   - Saturated unit weight: $\gamma_s := 115 \cdot pcf$
   - Dry unit weight: $\gamma_d := 110 \cdot pcf$
   - Internal friction angle: $\phi_{ns} := 0 \cdot deg$
   - Undrained shear strength: $c_{ns} := 300 \cdot psf$
3. Use Terzaghi strip equations as L>B
4. Effective stress analysis footing on ϕ-c soil (Bowles 5th Ed. Example 4-1 pg 231)

Depth the water table: $D_w := 0 \cdot ft$ Unit Weight of water: $\gamma_w := 62.4 \cdot pcf$

Effective stress at box bearing level: $q_{eff} := D_w \cdot \gamma_s + (D_{box} - D_w) \cdot (\gamma_s - \gamma_w)$ $q_{eff} = 0.105 \cdot ksf$

Look at 4 widths: $B := \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

Terzaghi Shape factors from Table 4-1 For a strip footing: $s_c := 1.0$ $s_\gamma := 1.0$

Meyerhof Bearing Capacity Factors - Bowles 5th Ed. table 4-4 pg 223

For ϕ=0 deg $N_c := 5.14$ $N_q := 1$ $N_\gamma := 0$

Nominal Bearing Resistance per Terzaghi equation (Bowles 5th Ed. Table 4-1 pg 220)

$q_{nominal} := c_{ns} \cdot N_c \cdot s_c + q_{eff} \cdot N_q + 0.5(\gamma_s) B \cdot N_\gamma \cdot s_\gamma$ $q_{nominal} = \begin{pmatrix} 1.6 \\ 1.6 \\ 1.6 \\ 1.6 \end{pmatrix} \cdot ksf$

Resistance Factor: $\phi_b := 0.45$ AASHTO LRFD Table 10.5.5.2.2-1

$q_{factored} := q_{nominal} \cdot \phi_b$ $q_{factored} = \begin{pmatrix} 0.7 \\ 0.7 \\ 0.7 \\ 0.7 \end{pmatrix} \cdot ksf$ $B = \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

At Strength Limit State:

Limit factored bearing resistance of 1 ksf for box culvert with a 12 foot opening and 1 foot thick walls and a 2 foot overbuild on each side of box walls (B=18 feet)

Bearing Resistance - Compacted Fill

Foundations on Dense or Compacted Sand Overlying Soft Clay
Reference: Das, Principles of Foundation Engineering, Second Edition, Page 151, Equation 3.58

Footing Width and Depth:

Box opening is 12 ft + (2) 1-foot walls + 2-foot overbuild of mat on each side of box walls = 18 feet

Look at 4 widths: $B := \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

Soil Statigraphy - Box embedded 2 feet and placed on 2 feet of Compacted Fill

Assumptions:

Depth to water table: $D_w := 0 \cdot ft$ Unit Weight of water: $\gamma_w := 62.4 \cdot pcf$

Depth of box bottom: $D_f := 2 \cdot ft$

Unit weight and friction angle for 3/4-inch stone wrapped in geotextile:

Saturated unit weight: $\gamma 1_{sat} := 130 \cdot pcf$

Dry unit weight: $\gamma 1_{dry} := 125 \cdot pcf$

Internal friction angle: $\phi := 40 \cdot deg$

Undrained shear strength: $c_1 := 0 \cdot psf$

Thickness of compacted fill: $H := 2 \cdot ft$

Vesic Bearing Capacity Factors - Das Table 3.2

For ϕ=40 deg $N_q := 64.2$ $N_\gamma := 109.41$

Medium Stiff SILT underlain by Soft Silty Clay - all underlying 2-foot Compacted Fill Mat

For ϕ=0 deg $N_c := 5.14$ Vesic Bearing Capacity Factors - Das Table 3.2

Silty clay undrained shear strength based on vane shear testing: $c := 350 \cdot psf$

Unit weight of silty clay: $\gamma_{clay} := 125pcf$

Determine punching shear resistance coefficient - Ks - from Das Figure 3.21

Ratio $R := \frac{5.14 \cdot c}{(\gamma 1_{sat} - \gamma_w) \cdot N_\gamma}$ $R = 0.243 \cdot ft$

Therefore: $K_s := 6.0$

Method 1: Foundation on Compacted Sand overlying Soft Clay - Strip Foundations
Ref: Das, Principles of Foundation Engr., Equation 3.58 for Continuous Foundations

$$q_n := c \cdot N_c + \left(\gamma 1_{sat} - \gamma_w\right) \cdot H^2 \cdot \left(1 + \frac{2 \cdot D_f}{H}\right) \cdot K_s \cdot \frac{\tan(\phi)}{B} + \left(\gamma 1_{sat} - \gamma_w\right) \cdot D_f \qquad q_n = \begin{pmatrix} 2.226 \\ 2.189 \\ 2.161 \\ 2.138 \end{pmatrix} \cdot ksf$$

At Strength Limit State:

Resistance factor for bearing resistance: $\phi_b := 0.45$ AASHTO LRFD Table 10.5.5.2.2-1

$q_{factored} := q_n \cdot \phi_b$ $\quad q_{factored} = \begin{pmatrix} 1.002 \\ 0.985 \\ 0.972 \\ 0.962 \end{pmatrix} \cdot ksf$ for these widths: $B := \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

with a maxmium of: $q_{max} := \left[\frac{1}{2} \cdot \left(\gamma 1_{sat} - \gamma_w\right) \cdot B \cdot N_\gamma + D_f \cdot \left(\gamma 1_{sat} - \gamma_w\right) \cdot N_q\right]$ Das Equation 3.59

$q_{max} = \begin{pmatrix} 60.453 \\ 67.849 \\ 75.245 \\ 82.641 \end{pmatrix} \cdot ksf$ $\quad q_f := q_{max} \cdot \phi_b$ $\quad q_f = \begin{pmatrix} 27.204 \\ 30.532 \\ 33.86 \\ 37.188 \end{pmatrix} \cdot ksf$ This does not control

Method 2: Foundation on Compacted Sand overlying Soft Clay - Rectangular Foundations
Ref: Das, Principles of Foundation Engr., Equation 3.60 for Rectangular Foundations

Length of box culvert: $L := 78 \cdot ft$

Internal friction angle: $\phi = 40 \cdot deg$

$$q_n := \left(1 + 0.2 \cdot \frac{B}{L}\right) c \cdot N_c + \left[\left[\left(1 + \frac{B}{L}\right) \cdot \left(\gamma 1_{sat} - \gamma_w\right) \cdot H^2 \cdot \left(1 + \frac{2 \cdot D_f}{H}\right) \cdot K_s \cdot \frac{\tan(\phi)}{B}\right]\right] + \left(\gamma 1_{sat} - \gamma_w\right) \cdot D_f$$

$$q_n = \begin{pmatrix} 3.186 \\ 3.196 \\ 3.205 \\ 3.214 \end{pmatrix} \cdot ksf$$

At Strength Limit State:

Resistance factor for bearing resistance: $\phi_b := 0.45$ AASHTO LRFD Table 10.5.5.2.2-1

$q_{factored} := q_n \cdot \phi_b$ $\quad q_{factored} = \begin{pmatrix} 1.434 \\ 1.438 \\ 1.442 \\ 1.446 \end{pmatrix} \cdot ksf$ for these widths: $B := \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

Method 3: Foundation on Compacted Sand overlying Soft Clay - Rectangular Foundations
Use undrained shear strength of medium stiff silt (500 psf)
Ref: Das, Principles of Foundation Engr., Equation 3.60 for Rectangular Foundations

Assumed undrained shear strength: $c := 500 \cdot psf$

Length of box culvert: $L := 78 \cdot ft$

$$q_n := \left(1 + 0.2 \cdot \frac{B}{L}\right) c \cdot N_c + \left[\left[\left(1 + \frac{B}{L}\right) \cdot \left(\gamma 1_{sat} - \gamma_w\right) \cdot H^2 \cdot \left(1 + \frac{2 \cdot D_f}{H}\right) \cdot K_s \cdot \frac{\tan(\phi)}{B}\right]\right] + \left(\gamma 1_{sat} - \gamma_w\right) \cdot D_f$$

Determine punching shear resistance coefficient - Ks - from Das Figure 3.21

Ratio $R := \frac{5.14 \cdot c}{\left(\gamma 1_{sat} - \gamma_w\right) \cdot N_\gamma}$ $R = 0.347 \cdot ft$

Therefore: $K_s := 7.0$

$$q_n = \begin{pmatrix} 3.985 \\ 3.998 \\ 4.011 \\ 4.025 \end{pmatrix} \cdot ksf$$

At Strength Limit State:

Resistance factor for bearing resistance: $\phi_b := 0.45$ AASHTO LRFD Table 10.5.5.2.2-1

$q_{factored} := q_n \cdot \phi_b$

$$q_{factored} = \begin{pmatrix} 1.793 \\ 1.799 \\ 1.805 \\ 1.811 \end{pmatrix} \cdot ksf$$

for these widths: $B := \begin{pmatrix} 14 \\ 16 \\ 18 \\ 20 \end{pmatrix} \cdot ft$

Recommend 1.8 ksf for factored bearing resistance at the Strength Limit State.

Frost Protection:

Method 1 - MaineDOT Design Freezing Index (DFI) Map and Depth of Frost Penetration Table are in BDG Section 5.2.1.

From the Design Freezing Index Map:
Franklin, Maine
DFI = 1300 degree-days

Assume box will be founded on compacted granular soils with water content ~= 10%

From Table 5-1 MaineDOT BDG for Design Freezing Index of 1300 and wc =10%
Frost Penetration = 76.3 inches

$Frost\_depth := 76.3in$ $Frost\_depth = 6.4 \cdot ft$

Method 2 - Check Frost Depth using Modberg Software

Closest Station is Ellsworth

ModBerg Results
Project Location: Ellsworth, Maine

Air Design Freezing Index	=	1256 F-days
N-Factor	=	0.80
Surface Design Freezing Index	=	1005 F-days
Mean Annual Temperature	=	44.6 deg F
Design Length of Freezing Season	=	126 days

Layer #:Type	t	w%	d	Cf	Cu	Kf	Ku	L
1-Coarse	66.4	10.0	125.0	28	34	2.0	1.6	1,800

t = Layer thickness, in inches.
w% = Moisture content, in percentage of dry density.
d = Dry density, in lbs/cubic ft.
Cf = Heat Capacity of frozen phase, in BTU/(cubic ft degree F).
Cu = Heat Capacity of thawed phase, in BTU/(cubic ft degree F).
Kf = Thermal conductivity in frozen phase, in BTU/(ft hr degree).
Ku = Thermal conductivity in thawed phase, in BTU/(ft hr degree).
L = Latent heat of fusion, in BTU / cubic ft.

****
Total Depth of Frost Penetration = 5.53 ft = 66.4 in.
****

$Frost\_depth_{modberg} := 66.4 \cdot in$

$Frost\_depth_{modberg} = 5.533 \cdot ft$ Use Frost Depth = 5.5 feet for design

Appendix D

Special Provisions

SPECIAL PROVISION
SECTION 203
CRUSHED STONE

Description This work shall consist of constructing a leveling pad of crushed stone in accordance with these specifications and in reasonably close conformity with the width, grade and thickness shown on the plans or established by the Resident.

MATERIALS

Aggregate Crushed stone material shall meet the requirements of ASTM Standard Specification C33, Standard Specification for Concrete Aggregates.

The aggregate shall meet the following gradation requirements:

Particle size	Percent by Weight Passing
1 inch	100
¾ inch	90 – 100
½ inch	20 – 55
⅜ inch	0 – 15
No. 4	0 - 5

Construction Requirements The crushed stone shall be placed and graded as shown on the plans or as directed by the Resident. The crushed stone shall be compacted as required to ensure that all voids in the stone are filled, as approved by the Resident.

Method of Measurement Aggregate for crushed stone will be measured by the cubic yard complete in place.

Basis of Payment The accepted quantity of crushed stone will be paid for at the contract unit price per cubic yard of aggregate complete in place.

Payment will be under

Pay Item	Unit
203.35 Crushed Stone	Cubic Yard

SPECIAL PROVISION 534
PRECAST STRUCTURAL CONCRETE
(Precast Structural Concrete Arches, Box Culverts, Frames)

The following replaces Section 534 in the Standard Specifications in its entirety:

534.01 Description The Contractor shall design, manufacture, furnish, and install elements, precast structural concrete structures, arches, box culverts or three sided frames and associated wingwalls, headwalls, toe walls/cut off walls and appurtenances, in accordance with the Contract Documents.

534.02 Materials Structural precast elements for the arch, box culvert, or frame and associated precast elements shall meet the requirements of the following Subsection except as noted otherwise in this specification:

Structural Precast Concrete Units	712.061

New concrete mix designs and mix designs not previously approved by the Fabrication Engineer, including Self-Consolidating Concrete (SCC) mixes, shall be qualified by trial batches prepared in accordance with AASHTO T 126 (ASTM C 192). The test results shall demonstrate that the concrete meets the requirements of the Plans and this Specification. If accelerated curing is to be used in production, the test specimens shall be similarly cured.

Grout, concrete patching material, and geotextiles shall be one of the products listed on the Department's list of prequalified materials, unless otherwise approved by the Department.

Bedding and backfill material shall consist of Standard Specification 703.19, Granular Borrow, Material for Underwater Backfill, with the additional requirement that the maximum particle size be limited to 4 inches, or as shown on the Plans.

534.03 Drawings Prepare shop detail, erection and other necessary Working Drawings in accordance with Section 100 of the Standard Specifications. The Department will review and approve the drawings in accordance with the applicable requirements of Section 100 of the Standard Specifications. Changes and revisions to the approved Working Drawings shall require further approval by the Fabrication Engineer.

Concrete mix designs shall be part of the Working Drawing submittal. Include aggregate specific gravity, absorption, percent fracture, fineness modulus and gradation as part of the mix design. Provide the mix design calculations demonstrating how the batch weights, water-cement ratio and admixture dosage rate were determined.

534.04 Design Requirements The Contractor shall design the precast structural concrete structure in accordance with the AASHTO LRFD Bridge Design Specifications, latest edition. The HL-93 live load specified in the AASHTO LRFD Bridge Design Specifications shall be used for all limit states except for Strength I. The live load used for the Strength I

limit state shall be the Maine Modified live load which consists of the standard HL-93 Live Load with a 25% increase in the Design Truck. (Wheel loads based on the Design Truck shall be increased 25%). In addition, if the governing load rating factor based on the HL-93 live load is equal to or less than 1.10 a load rating based on the Maine legal truck (Configuration #6) shall also be checked to insure the rating factor is equal to or greater than 1.0.

The live load deflection check per AASHTO LRFD Bridge Design Specifications Section 2.5.2.6.2 for the top slab of box culverts and frames with clear spans 15 feet or greater and cover depths of 4 feet or less is mandatory. The live load deflection check shall be documented in the design computations submittal.

Design calculations that consist of computer program generated output shall be supplemented with at least one hand calculation and graphic demonstrating the design methodology used. The hand calculation shall document at a minimum the Strength I load case flexural design check of the top slab positive moment reinforcing steel. Design calculations shall provide thorough documentation of the sources of equations used and material properties.

The design shall be load rated in accordance with the AASHTO Manual for Bridge Evaluation, latest edition by the LRFR method and in accordance with the MaineDOT Load Rating Guide.

The Contractor shall submit design calculations, load rating if applicable and working/shop drawings for the precast structure to the Department for approval. A Licensed Professional Engineer, licensed in accordance with State of Maine laws, shall sign and seal all design calculations and drawings. Drawings shall conform with Section 105.7 - Working Drawings.

The Contractor shall submit the following items for review by the Resident at least forty five (45) working days prior to production:

A) The name and location of the manufacturer.
B) Method of manufacture and material certificates.
C) Description of method of handling, storing, transporting, and erecting the members.
D) Design computations (bound and indexed)
E) Load rating computations and completed load rating form (bound and indexed)
F) Shop Drawings with the following minimum details:

1) Fully dimensioned views showing the geometry of the members, including all projections, recesses, notches, openings, block outs, and keyways.
2) Details and bending schedules of reinforcing steel including the size, spacing, and location. Reinforcing provided under lifting devices shall be shown in detail.
3) Details and locations of all items to be embedded.
4) Total weight of each member.

534.05 Facilities for Inspection Provide a private office at the fabrication plant for the Department's inspection personnel, or Quality Assurance Inspectors (QAI's). The office shall be in close proximity to the Work. The office shall be climate controlled to maintain the temperature between 68° F and 75° F and have the exit(s) closed by a door(s) equipped with a lock and 2 keys which shall be furnished to the QAI's.

The QAI's office shall meet the following minimum requirements:

Description	Quantity
QAI's office (minimum ft^2)	100
Drafting Table Surface (ft^2)	35
Drafting stools-each	1
Office Desk	1
Ergonomic Swivel Chairs	1
Folding Chairs	2
Cordless telephone	1
Answering machine	1
High-speed internet connection (ports)	1
Fluorescent Lighting of 100 ft-candles minimum for all work areas	2
110 Volt 60 Cycle Electric Wall Outlets	3
Wall Closet	1
Plan Rack	1
Waste Basket with trash bags	1
Two-drawer file cabinet (locking)	1
Broom	1
Dustpan	1
Cleaning Materials	1
Water Cooler	1

The Contractor will be responsible for disposing of trash and supplying commercially bottled water for the water cooler.

The QAI will have the option to reject any furniture or supplies provided to the QAI's office, based on general poor condition.

Provide parking space for the QAI(s) in close proximity to the entrance to the QAI's office. Maintain the pathway between the parking area and the QAI's office so that it is free of obstacles, debris, snow and ice.

The facilities and all furnishings shall remain the property of the Contractor upon completion of the Work. Payment for the facilities, heating, lighting, telephone installation, internet connection, basic monthly telephone and internet charges and all furnishings shall be incidental to the Contract.

Failure to comply with the above requirements will be considered denial of access to the Work for the purpose of inspection. The Department will reject all Work done when access for inspection is denied.

534.06 Notice of Beginning Work Give the Department a minimum of two weeks notice for in-state work and three weeks notice for out-of-state work prior to beginning production. If the production schedule changes, notify the Fabrication Engineer no less than three (3) working days prior to the initial start-up date. Any Work done without the QAI present will be rejected. Advise the Fabrication Engineer of the production schedule and any changes to it. If Work is suspended on a project, the Fabrication Engineer will require 72 hours notice prior to the resumption of Work.

534.07 Quality Control Quality Control (QC) is the responsibility of the Contractor.

Provide a copy of the Quality System Manual (QSM) to the Fabrication Engineer if requested.

Inspect all aspects of the Work in accordance with the Contractor's QSM. Reject materials and workmanship that do not meet Contract requirements.

Record measurements and test results on the appropriate forms from APPENDIX E of Precast/Prestressed Concrete Institute Manual for Quality Control for Plants and Production of Structural Precast Concrete Products MNL 116 or an equivalent form prepared by the user. Provide copies of measurements and test results to the QAI as follows:

Type of Report	When Provided to QAI*
Aggregate gradations-fine aggregate and coarse aggregate	Prior to beginning work and at least once a week thereafter
Material certifications / stressing calculations / calibration certifications	Prior to beginning work (anticipate adequate time for review by QAI)
Pre-pour inspection report	Prior to the concrete placement
Concrete Batch Slips	The morning of the next work day
Results of concrete testing	The morning of the next work day
Concrete temperature records	Provide with compressive testing (for release)
Non-conformance reports/repair procedures	Within 24 hours of discovery
Results of compressive testing (for design strength)	Prior to stopping curing / Prior to final acceptance
Post-pour inspection report	Prior to final acceptance

* The Contractor and QAI may, by mutual agreement, modify any part of the schedule; however, failure to provide the documentation when required by the Fabrication Engineer will result in the product being deemed unacceptable. The Contractor may perform testing in addition to the minimum required. The results of all testing shall be made available to the Department.

534.08 Quality Assurance Quality Assurance (QA) is the prerogative of the Department.

The QAI will witness or review documentation, workmanship, testing and assure the Work is being performed in accordance with the QSM.

The QAI has the authority to reject materials and products that do not meet the Contract requirements including Work rejected due to denial of access or the lack of adequate notice of the beginning of production. The acceptance of material or workmanship by the QAI will not prevent subsequent rejection, if the Work is unacceptable.

534.09 Rejections Correct or replace rejected material and/or workmanship. Generate a non-conformance report (NCR); provide a copy to the QAI and forward a copy to the Fabrication Engineer for determination of corrective action.

In the event that an item fabricated under this Specification does not meet the Contract requirements but is deemed suitable for use by the Department, said item may be accepted in accordance with Section 100 of the Standard Specifications (see 106.8).

534.10 Forms and Casting Beds Construct forms to conform to the Working Drawings. The forms shall be well constructed, carefully aligned and sufficiently tight to prevent leakage of mortar. Reject forms that do not maintain the Plan dimensions. Inspect the bulkheads after each cast and repair or replace worn or damaged pieces.

Seal wooden forms to prevent absorption of water. Apply and cure the sealer in accordance with the manufacturer's product data sheet.

Remove all paint, adherent material, foreign matter and debris prior to placing concrete.

Apply a non-staining bond-breaking compound to the forms in accordance with the manufacturer's product data sheet. Solvent clean reinforcing steel and welded steel wire fabric contaminated with the bond-breaking compound.

534.11 Reinforcing Steel Fabricate, package, handle, store, place, splice and repair reinforcing steel in accordance with Section 503 of the Standard Specifications.

Accurately locate and securely anchor the reinforcing steel to prevent displacement during concrete placement. Install and secure all reinforcing steel prior to beginning the concrete placement.

The concrete cover shown on the approved Working Drawings shall be the minimum allowable cover. Use sufficient bar supports and spacers to maintain the minimum concrete cover. The bar supports and spacers shall be made of a dielectric material or other material approved by the Fabrication Engineer.

If reinforcing steel is not noted on the plans or drawings, the minimum amount of steel required shall be the area of steel equal to a grid of No. 4 bars at 18 inches in both directions, horizontally and vertically. Only one mat of steel is required for concrete thickness of 7 inches or less; two mats, one each face is required for thickness greater than 7 inches.

534.12 Voids and Inserts Voids shall be non-absorbent. The out-to-out dimensions of the voids shall be within 2% of Plan dimensions. Repair damaged voids in a manner acceptable to the Fabrication Engineer. Store, handle and place voids in a manner that prevents damage.

Accurately locate and securely anchor, securely cap and vent the voids in the form. Any portion of a void that is displaced beyond the allowable dimensional tolerances shall be cause for rejection of the slab or beam.

Open the void drains immediately upon removing the product from the form.

Recess inserts, ties or other steel items a minimum of 1 inch from the surface unless noted otherwise on the Plans. Any recess shall be filled with a product from the Department's Qualified Products List. The QAI is not responsible for verifying the location of inserts or other hardware installed for the convenience of the Contractor.

534.13 Concrete Placement Do not batch or place concrete until all the form(s) for any continuous placement have been inspected and accepted by the QCI and the QAI concurs.

Test concrete in accordance with the following Standards:

AASHTO T23 (ASTM C 31) Practice for Making and Curing Concrete Test Specimens in Field
AASHTO T 22 (ASTM C 39) Test Method for Compressive Strength of Cylindrical Concrete Specimens
AASHTO T119 (ASTM C 143) Test Method for Slump of Hydraulic Cement Concrete
AASHTO T141 (ASTM C 172) Practice for Sampling Freshly Mixed Concrete
AASHTO T152 (ASTM C 231) Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 1064-Test Method for Temperature of Freshly mixed Portland Cement Concrete
ASTM C 1611/C 1611M-05-Standard Test Method for Slump Flow of Self-Consolidating Concrete

Test the first two loads of concrete for temperature, air entrainment and slump, or spread for SCC. If the first load is unacceptable, test the second load as the first. Continue this process until two consecutive loads are acceptable. After two consecutive cylinders are acceptable, the frequency of testing shall be at the discretion of the QAI.

Test the concrete for temperature, air entrainment and slump, or spread for SCC, if there is a change in the dosage rate of any admixture, a change of three inches or more in slump or a change of more than 5° F in mix temperature.
Test every load of 1 cubic yard, or less, from a stationary mixer or 2 cubic yards, or less, from a transit mixer for temperature, air entrainment and slump, or spread for SCC, prior to placing the concrete in the forms.

Perform all testing in the presence of the QAI. The QAI will designate the loads to be tested. Make cylinders used to determine stripping strength during the last 1/3 of the placement.

Place the concrete as nearly as possible to its final location. Control the depth of each lift in order to minimize entrapped air voids. The maximum depth of an unconsolidated lift shall be 18 inches. Vibrate the concrete with internal or internal and external vibrators. Do not use external vibrators alone. Insert internal vibrators vertically and penetrate the lower layer of concrete by at least 4 inches. Insert the vibrators in the concrete to assure that the radii of action of the vibrators overlap. Hold the vibrators in position from 5 to 15 seconds. Do not use vibrators to move concrete horizontally. Each lift of concrete shall have sufficient plasticity to be consolidated with subsequent lifts.

Do not re-temper the concrete with water after discharging has begun. The Contractor may add HRWR to the concrete after batching if that practice conforms to the manufacturer's product data sheet. Discard concrete that becomes unworkable.

Do not use water or water-based products to aid in finishing fresh concrete.

After the concrete has been placed and finished and before the forms are covered, remove all concrete from projecting reinforcing steel

534.14 Process Control Test Cylinders Make concrete test cylinders for each day's casting. Cylinders tested to determine stripping strength and early design strength shall be field cured in accordance with AASHTO T23 (ASTM C 31). 28 day cylinders shall be standard cured. Record unit identification, entrained air content, water-cement ratio, slump and temperature of the sampled concrete at the time of cylinder casting. Once a week, make four cylinders for use by the Department. They shall be standard cured in accordance with AASHTO T23 (ASTM C 31).

If the Contractor fails to make enough cylinders to demonstrate that the product meets the Contract requirements, the product will be considered unacceptable.

The compressive strength of the concrete will be determined by averaging the compressive strength of two test cylinders made from the same sample. For the purpose of determining design strength, the average of two cylinders shall meet or exceed the design strength, and, neither cylinder shall have a compressive strength less than 90% of design strength.

Perform compressive testing to determine transfer and design strength in the presence of the QAI. Cylinder tests not witnessed by the QAI will not be acceptable.

534.15 Manufacture of Precast Units The cover of concrete over the outside circumferential reinforcement shall be 2 inches minimum. The concrete cover over the inside reinforcement shall be 1 ½ inches minimum. The clear distance of the end of circumferential wires shall not be less than 1 inch or more than 2 inches from the end of the sections. Reinforcement shall be single or multiple layers of welded wire fabric or a single layer of deformed billet steel bars.

Welded steel wire fabric shall meet the space requirements and contain sufficient longitudinal wires extending through the section to maintain the shape and position of the reinforcement. Longitudinal distribution reinforcement may be welded steel wire fabric or deformed steel bars which meet the spacing requirements. The ends of the longitudinal distribution reinforcement shall be not more than 3 inches from the ends of the sections.

Do not use more than three layers of reinforcing to form a single mat. If reinforcing steel is cut to install lifting devices install additional reinforcing adjacent to the cut steel.

Tension splices in the reinforcement will not be permitted. For splices other than tension splices, the overlap shall be a minimum of 12 inches for welded steel wire fabric or deformed steel bars. The spacing center to center of the circumferential wires in a wire fabric sheet shall be not less than 2 inches or more than 4 inches. For the wire fabric, the spacing center to center of the longitudinal wires shall not be more than 8 inches. The spacing center to center of the longitudinal distribution steel for either line of reinforcing in the top slab shall not be more than 15 inches.

The members shall be free of fractures. The ends of the members shall be normal to the walls and centerline of the section, within the limits of variation provided, except where beveled ends are specified. The surfaces of the members shall be a smooth steel form or troweled surface finish, unless a form liner is specified. The ends and interior of the assembled structure shall make a continuous line of members with a smooth interior surface.

Defects which may cause rejection of precast units include the following:

1) Any discontinuity (crack or rock pocket etc.) of the concrete which could allow moisture to reach the reinforcing steel.
2) Rock pockets or honeycomb over 6 square inches in area or over 1 inch deep.
3) Edge or corner breakage exceeding 12 inches in length or 1 inch in depth.
4) Extensive fine hair cracks or checks.
5) Any other defect that clearly and substantially impacts the quality, durability, or maintainability of the structure as measured by accepted industry standards.

The manufacturer of the members shall sequentially number and shop fit each adjacent member to ensure that they fit together in the field. This fit up shall be witnessed by the QA

inspector. Any non-fitting members shall be corrected or replaced at no cost to the Department.

Documentation The producer of the structural precast units shall keep accurate records of aggregate gradations, concrete batching, testing, curing, and inspection activities to verify that forms, reinforcing and unit dimensions conform to these requirements. Copies of reports shall be furnished to the Resident when requested.

534.16 Tolerances Dimensional tolerances shall be in conformance with the applicable reference specification or the established industry standards for the product being produced. The internal dimensions shall not vary by more than 1 percent from the design dimensions or 1 ½ inches, whichever is less with the exception of the cross diagonal dimension which shall not vary by more than ½ inch from the design dimension. The haunch dimensions shall not vary by more than ¾ inch from the design dimension. The dimension of the legs shall not vary by more than ¼ inch from the dimension shown on the approved shop drawings.

The slab and wall thickness shall not be less than the design thickness by more than ¼ inch. A thickness greater than the design thickness shall not be cause for rejection.

Variations in laying lengths of two opposite surfaces shall not be more than ⅝ inch in any section, except where beveled ends for laying of curves are specified.

The under-run in length of any section shall not be more than ½ in.

534.17 Finishing Concrete Products shall meet ordinary finish requirements per subsection 502.14. Fascia members shall receive a rubbed finish per subsection 502.14. The Contractor may use alternative methods of achieving an acceptable finish on fascia members if approved by the Fabrication Engineer.

Marking The date of manufacture, the production lot number, and the type of unit shall be clearly and indelibly scribed on a rear, unexposed portion of each unit.

543.18 Repairing Defects Exposed surfaces shall be of uniform appearance; only minor repairs to remove and blend fins, patch minor spalls and to repair small, entrapped air pockets shall be permitted. Units that are cracked or require surface repairs larger than 2 in^2 or an accumulated repair area greater than 10% of the surface being repaired may be rejected.

Repair honeycombing, ragged or irregular edges and other cosmetic defects using a patching material from the MaineDOT Qualified Products List. The repair, including preparation of the repair area, mixing and application and curing of the patching material, shall be in accordance with the manufacturer's product data sheet. Corners not exposed in the final product may be ground smooth with no further repair necessary if the depth of the defect does not exceed ½ inch. Remove form ties and other hardware to a depth of not less than 1 inch from the face of the concrete and patch the holes using a patching material from the MaineDOT Qualified Products List.

Repair structural defects only with the approval of the Fabrication Engineer. Submit a non-conformance report (NCR) to the Fabrication Engineer with a proposed repair procedure. Do not perform structural repairs without an approved NCR. Structural defects include, but are not be limited to, exposed reinforcing steel or strand, cracks in bearing areas, through cracks and cracks 0.013 inch in width that extend more than 12 inches in length in any direction. Give the QAI adequate notice prior to beginning structural repairs.

534.19 Handling, Storage and Transportation Handle store and transport members in a manner as to eliminate the danger of chipping, cracks, fracture, and excessive bending stresses. Any units found damaged upon delivery, or damaged after delivery, shall be subject to rejection.

Do not place precast members in an upright position until a compressive strength of at least 4350 psi is attained. Precast products a may be handled and moved, but do not transport products until the 28 day design strength has been attained.

Support stored precast/prestressed products above the ground on dunnage in a manner to prevent twisting or distortion. Protect the products from discoloration and damage.

534.20 Installation of Precast Units Do not ship precast members until sufficient strength has been attained to withstand shipping, handling and erection stresses without cracking, deformation, or spalling. A minimum strength of 4350 psi shall be attained prior to shipping in all cases.

Set precast members on ½ inch neoprene pads during shipment to prevent damage to the section legs. The Contractor shall repair any damage to precast members resulting from shipping or handling by saw cutting a minimum of ½ inch deep around the perimeter of the damaged area and placing a polymer-modified cementitious patching material.

When footings are required, install the precast members on concrete footings that have reached a compressive strength of at least 2900 psi. Construct the completed footing surface to the lines and grades shown on the Plans. When checked with a 10 foot straightedge, the surface shall not vary more than ¼ inch in 10 feet. The footing keyway shall be filled with a non-shrink flowable cementitious grout with a design compressive strength of at least 5000 psi.

Box culvert joints shall be sealed with an approved flexible joint sealant in accordance AASHTO M 198 (ASTM C 990). Joints shall be closed tight to within 0.625 inches ±0.125 inch. Culvert sections shall be equipped with joint closure mechanisms to draw sections together and close joints to the required opening.

Fill holes that were cast in the units for handling, with either Portland cement mortar, or with precast plugs secured with Portland cement mortar or other approved adhesive. Completely fill the exterior face of joints between precast members with an approved material and cover with a minimum 12 inch wide joint wrap. The surface shall be free of dirt and deleterious

materials before applying the filler material and joint wrap. Install the external wrap in one continuous piece over each member joint, taking care to keep the joint wrap in place during backfilling. Seal the joints between the end unit and attached elements with a non-woven geotextile. Install and tighten the bolts fastening the connection plate(s) between the elements that are designed to be fastened together as designated by the manufacturer.

Place and compact the bedding material as shown on the plans prior to lifting and setting the culvert sections. Backfill the structure in accordance with the manufacturer's instructions and the Contract Documents. Uniformly distribute backfill material in layers of not more than 8 inches in depth, loose measure, and thoroughly compact each layer using approved compactors before successive layers are placed. Compact the Granular Borrow bedding and backfill in accordance with Section 203.12 - Construction of Earth Embankment with Moisture and Density Control, except that the minimum required compaction shall be 92 percent of maximum density as determined by AASHTO T-180, Method C or D. Place and compact the backfill without disturbance or displacement of the structure, keeping the fill at approximately the same elevation on both sides of the structure. Whenever a compaction test fails, the Contractor shall not place additional backfill over the area until the lift is re-compacted and a passing test achieved.

Use hand-operated compactors within 5 feet of the precast structure as well as over the top until it is covered with at least 12 inches of backfill. The Contractor shall take adequate precautions to protect the top of the culvert from damage during backfilling and/or paving operations. Any damage to the top of the culvert shall be repaired or members replaced at no cost to the Department.

534.21 Method of Measurement The Department will measure Precast Structural Concrete Arch, Box Culvert or three sided Frames for payment per Lump Sum each, complete in place and accepted.

534.22 Basis of Payment The Department will pay for the accepted quantity of Precast Structural Concrete Arch (Including Frames) or Precast Concrete Box Culvert at the Contract Lump Sum price, such payment being full compensation for all labor, equipment, materials, professional services, and incidentals for furnishing and installing the precast concrete elements and accessories. Falsework, reinforcing steel, welded steel wire fabric, jointing tape, geotextile, grout, cast-in-place concrete fill or grout fill for anchorage of precast wings and/or other appurtenances is incidental to the Lump Sum pay item. Cast-in-place concrete, reinforcing steel in cast-in-place elements, and membrane waterproofing will be measured and paid for separately under the provided Contract pay items. Pay adjustments for quality level will not be made for precast concrete.

Payment will be made under:

Pay Item		Pay Unit
534.70	Precast Structural Concrete Arch	Lump Sum
534.71	Precast Concrete Box Culvert	Lump Sum