ADDENDUM NO. 1

GEOTECHNICAL ENGINEERING REPORT

Backland Pavement
Port of Port Arthur Berth 5
221 Houston Avenue
Port Arthur, Texas

Schnabel Reference 17C13205
September 11, 2018

Prepared For:

COLLINS ENGINEERS INC

Schnabel ENGINEERING

Schnabel ENGINEERING

September 11, 2018

Mr. Dan O'Connor, PE
Collins Engineers, Inc.
650 Islington St., Suite 1
Portsmouth, NH 03801

Subject: **Project 17C13205, Addendum No. 1, Geotechnical Engineering Report, Backland Pavement, Port of Port Arthur Berth 5, 221 Houston Avenue, Port Arthur, Texas**

Dear Mr. O'Conner:

Schnabel Engineering, LLC. (Schnabel), prepared a Geotechnical Engineering Report (GER) for this project dated March 14, 2018. The GER contained our evaluation of the subsurface conditions below the backland slab, a summary of our soil laboratory testing, estimated time-dependent ground settlement of the backland slab, and geotechnical recommendations for the design and support of a concrete backland slab. Our GER also contained a discussion of several constructability issues related to the planned bulkhead and backland slab construction.

1.0 PROJECT BACKGROUND

We understand that due to the constructability issues, the design and planned construction for the Berth 5 bulkhead and backland slab has changed. The current design eliminates the section of the bulkhead improvements along the existing bulkhead; eliminates the soil anchors; and eliminates the concrete backland slab and the planned container storage on the backland slab.

We understand that the Port would like to install a new backland asphalt pavement after the Berth 5 reconstruction is completed and under a separate contract. The proposed backland pavement will be located behind and along the entire new Berth 5 wharf. The planned elevation of the backland pavement is at about EL 14, which is about 2 to 6 feet above the existing grades, except at Gunite Outfall (Grannis Ditch), where the backland pavement grade will be up to about 18-feet above the existing outfall grade. The backland pavement will be used as a transit way for trucks and port equipment. There will be no long-term storage of materials and equipment and the area will be used in such a manner as to not create long-term loading conditions. The following traffic data was provided to us by Collins Engineers and we assumed a growth rate of 1 percent-per year.

Table 1: Design Traffic Data

Equipment/Vehicle	Trips	Units	Total Passes (2 x trips) over life Span (20 Yr)
Forklifts			
Hyster 80	50	day	804222
Hyster 90	50	day	804222
Hyster 155	50	day	804222
Yale 155VX	50	day	804222
Container Lift Truck			
Hyster 1150HD	200	day	3216888
Vehicles			
HS20-44 Truck	100	day	1608444
Passenger Vehicle	10	day	160844
Shiploader			
B&W 50mx1400mm Belt	1	month	528
Bulldozer			
CAT D7R	1	month	528

In addition to the pavement design, we understand that Collins Engineers, Inc. would like an estimate of the equivalent uniform live loads that would cause estimated backland pavement settlement of about 1, 2, 3, and 4-inches.

An approach slab to transition from the backland pavement to the wharf in the area of the existing bulkhead is also planned. The current wharf construction documents prepared by LAN have a discontinuity between the existing bulkhead and the new wharf. The clear “gap” is approximately 1.5 feet. An approach slab is planned to transition from the backland pavement to the bulkhead, over the “gap”. The approach slab is anticipated to be approximately 25-feet long and will be installed in the area behind the existing bulkhead (within the area of the existing relieving platform and behind the new bulkhead).

This addendum includes design recommendations for the planned backland asphalt pavement; estimated long-term live load surcharge on the backland pavement that would result in settlements of about 1, 2, 3 and 4-inches; and estimated settlements adjacent to the bulkhead for use in the design of the planned approach slab over the 1.5-feet clear “gap”.

This addendum was prepared per your request and in accordance with our agreement, dated June 6, 2018.

2.0 BACKLAND PAVEMENT RECOMMENDATIONS

2.1 Pavement Subgrades

New pavements will be constructed for the Berth 5 backland. The planned elevation of the backland pavement is at about EL 14. Based on the existing site grades and the planned grades, we expect that about 2-feet of fill (including pavement section) is expected near the south end of the bulkhead; about 6-feet of fill (including pavement section) is expected at the western edge of the backland pavement; up to about 18-feet of fill (including pavement section) is expected at the Gunite Outfall (Grannis Ditch) structure near the proposed bulkhead; and about 4-feet of fill (including pavement section) is expected adjacent to Transit Shed #3 to reach the proposed site grades.

Based on our discussions with Collins Engineers, we anticipate that either: lightweight foamed glass aggregate fill (Alt A); or lightweight expanded shale, clay or slate aggregate (ESCS) fill (Alt B) will be used to raise the site. Based on the resilient modulus test results of lightweight foamed glass aggregate (Alt A) provided to us by the manufacturer Aero Aggregate, the resilient modulus of lightweight foamed glass aggregate varied from 14,800 to 47,400 psi. The CBR testing on ESCS fill (Alt B) performed by the manufacturer Stalite, indicates a CBR value of 23 for the ESCS fill. For our pavement design, we used a resilient modulus of 14,800 psi – which equates to an equivalent CBR value of about 9.8.

We recommend that the suitability of the existing subgrades (except at the Grannis Ditch) be evaluated by a proofroll test prior to placement of the lightweight fills. The proofroll tests should be performed under the observation of a qualified geotechnical engineer. The geotechnical engineer should evaluate the suitability of the soils for fill support based on observations of proofrolling with a loaded 20-ton dump truck. Evaluation techniques may also include probing with a penetrometer, observing proofrolling, drilling hand augers, observing test pits, or a combination of these methods.

Where wet or soft subgrade soils, or soils that exhibiting excessive pumping, weaving, or rutting are encountered near the proposed pavement subgrade, the unsuitable soils (as determined by the geotechnical engineer) will require removal and replacement, or stabilization. Stabilization techniques such as undercutting and replacing with lightweight aggregate fill and the use of geotextile fabrics may also be considered and should be evaluated during the construction phase of the project by the geotechnical engineer. Our GER dated January 26, 2018 contains additional recommendations for subgrade preparation and stabilization.

2.2 New Pavements

The flexible backland asphalt pavement section was designed using the Pavement-Transportation Computer Assisted Structural Engineering (PCASE) software program. We designed the backland slab pavement using the traffic loads and volumes provided to us (included in Table 1), and assumed a nominal annual growth rate of 1-percent and a pavement design life of 20-years. We also assumed that the asphalt pavement will be supported on compacted lightweight aggregate fill with a minimum thickness of 1-foot.

Based on understanding of the traffic loading and site conditions discussed above, we recommend the following pavement sections for new backland pavement.

Table 2: Recommended New Asphalt Pavement Section
(20-YR DESIGN LIFE)

Layer Description	Layer Thickness (inch)
Superpave SP-D SAC-B PG 70-22 Surface Course (TxDOT Item 344)	2
HMA TY-C PG 70-22 Base Course (TxDOT Item 341) (two 3-inch lifts)	6
Graded Aggregate Base Flexible Base (TxDOT Item 247)	4
Geotextile Fabric	_
Lightweight Aggregate Fill Subgrade	>12

A sketch of the typical pavement detail is provided as Figure 1.

3.0 PAVEMENT SETTLEMENT - LIVE LOAD SURCHARGE THAT WOULD RESULT IN SETTLEMENTS OF 1, 2, 3 AND 4-INCHES

The subsurface soils at the backland pavement site consist of thick layers of highly compressible normally consolidated to slightly over-consolidated clays. These soils will undergo significant and slow time-dependent consolidation settlement under the increased loading from the dead weight of the lightweight fill aggregates used to raise the site, the weight of the backland pavement, and from any long-term live load surcharge.

We performed settlement analysis of the underlying soils at the site to estimate the magnitude of the settlements over pavement design life of 20-years and at 100-years. The settlement analysis was performed using the ROCSCIENCE Settle3D, 3-dimensional program. The software performs settlement analysis of time-dependent vertical consolidation and elastic settlement under the proposed loading conditions under user defined horizontal and vertical drainage conditions. The elastic moduli of the soils were estimated from the Standard Penetration Test data, and the consolidation coefficients were estimated from the one-dimensional consolidation tests performed on undisturbed samples collected during our subsurface exploration study. The soil parameters of the underlying soils at the site, used for the computations of the ground settlement (elastic and consolidation) under the backland pavement live loads, were estimated from the laboratory testing performed, the CPT testing, and from published correlations of SPT N-values. The design soil parameters, laboratory test data, and the CPT test data are contained in our GER dated January 26, 2018.

We evaluated the settlement of the underlying soils at the site under the new lightweight fills and proposed pavement section dead load and then varied the live load through an iterative process to evaluate the equivalent surcharge live loads that would produce ground settlements of about 1” (Case 1), 2” (Case 2), 3” (Case 3), and 4” (Case 4) over a 20-year pavement design life. It should be noted that the live loads were modeled as permanent static loads, and would result in larger calculated settlements. Therefore, the actual settlements of the underlying soils under temporary traffic loads will be less than the computed settlements shown below.

We evaluated total settlement along a line parallel to and immediately behind the bulkhead; and along a line parallel to the bulkhead and located in the middle of the backland pavement. Plate 1 below shows the settlement analysis lines near the bulkhead and in the center of the backland pavement.

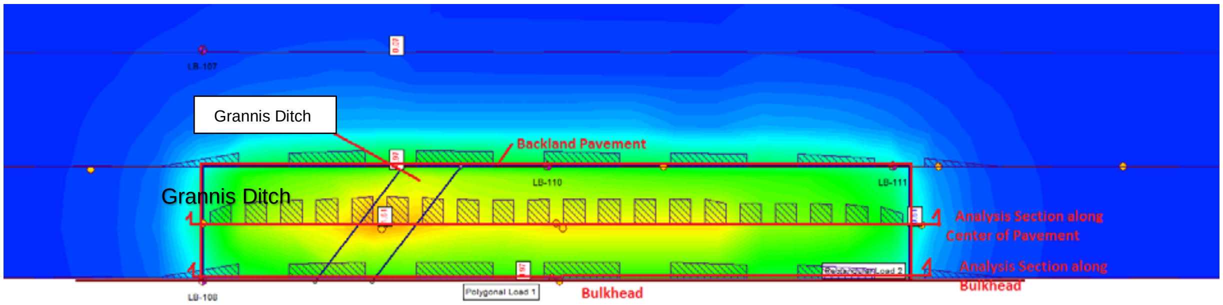

Plate 1: Location of Settlement Analysis Sections

For the lightweight foamed glass aggregate fill option (Alt A), we assumed a design moist unit weight of 22 pcf, and a saturated unit weight of 49 pcf for fill placed below the groundwater (total saturated weight).

For the lightweight expanded shale, clay or slate aggregate fill option (Alt B), we assumed a design unit weight of 70 pcf (saturated). The design unit weight is based on the material properties specified for ESCS materials in the LAN draft Earth Moving specifications.

Based on our settlement analysis, the following equivalent surcharge live loads that would produce ground settlements of 1” (Case 1), 2” (Case 2), 3” (Case 3), and 4” (Case 4) over a 20-year pavement design life are estimated:

Table 3: Summary of Estimated Surcharge Loads vs. Settlements at Middle of Pavement - Foamed Glass Aggregate Fill

Analysis Case	Surcharge Live Load (psf)	General Backland Pavement Area			Gunite Outfall Area		
		Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load at 20-years (inches)	Estimated Total Settlement at 100-years (inches)	Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load at 20-years (inches)	Estimated Total Settlement at 100-years (inches)
DL only	0	1.2	--	1.6	1.4	--	1.7
Case 1	260	2.2	~1.0	2.9	2.3	0.9	2.9
Case 2	410	3.2	~2.0	4.1	2.8	1.4	3.6
Case 3	530	4.2	~3.0	5.2	3.2	1.8	4.1
Case 4	650	5.2	~4.0	6.4	3.6	2.2	4.6

Table 4: Summary of Estimated Surcharge Loads vs. Settlements at Bulkhead - Foamed Glass Aggregate Fill

Analysis Case	Surcharge Loading (psf)	Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load Surcharge at 20-years (inches)	Estimated Total Settlement at 100-years (inches)
DL only	0	0.8	--	1.0
Case 1A	260	1.4	0.6	1.9
Case 2A	410	1.7	0.9	2.5
Case 3A	530	2.1	1.3	2.8
Case 4A	650	2.5	1.7	3.3

Table 5: Summary of Estimated Surcharge Loads vs Settlements at Middle of Pavement – ESCS Fill

Analysis Case	Surcharge Loading (psf)	General Backland Pavement Area			Gunite Outfall Area		
		Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load at 20-years (inches)	Estimated Total Settlement at 100-years (inches)	Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load at 20-years (inches)	Estimated Total Settlement at 100-years (inches)
DL only	0	1.7	--	2.3	2.8	--	3.4
Case 1B	190	2.7	~1.0	3.4	3.5	0.7	4.3
Case 2B	330	3.7	~2.0	4.6	4.2	1.4	5.1
Case 3B	450	4.7	~3.0	5.7	4.9	2.1	6.0
Case 4B	570	5.7	~4.0	6.9	5.7	2.9	6.9

Table 6: Summary of Estimated Surcharge Loads vs Settlements at Bulkhead - ESCS Fill

Analysis Case	Surcharge Loading (psf)	Estimated Total Settlement at 20-years (inches)	Estimated Settlement from Live Load at 20-years (inches)	Estimated Total Settlement at 100-years (inches)
DL only	0	1.8	--	2.4
Case 1a	192	1.9	0.5	2.4
Case 2a	330	2.2	0.6	2.8
Case 3a	450	2.4	0.7	3.1
Case 4a	570	2.7	0.7	3.4

3.1 Impact of Ground Settlements on Structures

If lightweight expanded shale, clay or slate aggregate fill option (Alt B) is used to fill the site, larger ground settlements should be expected than if lightweight foamed glass aggregate fill (Alt 1) is used. We believe that the estimated pavement settlements will impact the new backland pavement, the new bulkhead, existing tierods and A-Frame, new tiebacks, and existing and new underground utility structures. The settlements will also impact the existing Transit Shed #3 foundations and slab on grade floor, and the existing relieving platform behind Berth 5. Larger settlements over the life of a structure (including the new pavements) can cause more maintenance issues or more damage. A discussion of the potential adverse impacts of excessive settlements on the proposed and existing structures are provided in our GER.

Lightweight foamed glass aggregate fill (Alt A) is not available locally in Texas, but is available from Aero Aggregates, located in Eddystone Pennsylvania. Lightweight expanded shale, clay or slate aggregate (ESCS) fill (Alt B) is available locally in Texas. We recommend that the Port perform a cost analysis to evaluate the magnitude of the differences in the cost of the two materials, and evaluate if the reduced cost (if any) for the lightweight expanded shale, clay or slate aggregate fill (Alt 2) outweighs the benefit of less ground settlements and related reduced maintenance issues or damages, if lightweight foamed glass aggregate fill (Alt A) is used.

3.1.1 Impact of Ground Settlements at Grannis Ditch

If lightweight aggregate fill is used to fill the Grannis Ditch, the ground settlement at the Grannis Ditch from the fill dead load is not expected to be significantly different from the ground settlements near the center of the backland pavement. We estimate settlements of less than ½ inch over a 20-year design life if lightweight foamed glass aggregate fill (Alt A) is used, and about 1-inch if lightweight expanded shale, clay or slate aggregate (ESCS) fill (Alt B) is used. Therefore, we believe that a pile supported structural slab over the Grannis Ditch is not necessary. The estimated settlements does not consider any dead load or live load surcharges.

4.0 APPROACH SLAB

We understand that the approach slab, spanning the 18-inch “gap” between the bulkhead and the new wharf, will be designed so that one end of the slab is supported on the wharf and the other end supported on the backland. The new wharf is designed by LAN to be supported on piles. We recommend that the approach slab be designed to consider the estimated settlements at the Berth 5 bulkhead, so that the differential settlement between the ends of the approach slab founded on the wharf and on the pavement are within tolerable limits after the pavement settlement has occurred. The approach slab should not connect to or rest on the existing bulkhead. A minimum separation of 5-inches is recommended between the approach slab and the top of the existing bulkhead.

We considered spread footings suitable for support of the proposed approach slab. Footings should be founded on the lightweight aggregate fill or on suitable existing stiff Silty Lean Clay and/or medium dense Silty Sand fill soils at the site. We recommend footings supported on the lightweight aggregate fill or on suitable existing fill soils be designed for a net allowable soil bearing pressure of 2,000 psf. This bearing pressure provides a factor of safety against general bearing capacity failure of at least 3.0.

All footing subgrades should be observed by the Geotechnical Engineer prior to placement of concrete to evaluate if the subgrade materials are as anticipated.

If unsuitable soils are encountered at the design bearing grade, these soils should be removed and replaced with additional lightweight aggregate fill, as recommended by the Geotechnical Engineer.

The approach slab footings should be at least 24 inches wide for shear considerations. The site location is not frost susceptible, however, for stability of the foundations, we recommend that the footings be founded at least 2 ft below final grades.

5.0 COMPACTED FILL

We recommend that any impervious surface (such as asphalt or concrete slabs) at the site be removed or the surface punctured to permit drainage of any water collected within the lightweight fills to the soils below. Therefore, the ditch liner for the Grannis Ditch should be removed or punctured.

The earthwork specifications should be adapted to address special handling and placement requirements for the recommended lightweight aggregate fills.

We further recommend that underdrains consisting of subdrainage piping connected to a drainage system be included in the lightweight aggregate fills to prevent the collection of water within the fill. The underdrain system should be installed on the lightweight fill subgrades along a minimum of lines parallel to the bulkhead; and located in the middle of the backland pavement, and at the western end of the backland pavement.

The subdrainage piping should consist of slotted corrugated polyethylene tubing per ASTM F-405. The maximum slot width should be 1/8-inch. Aggregate filter material should be placed around the tubing and the filter material should be wrapped in a geotextile fabric to limit infiltration of fines into the pipe. The aggregate filter material to be placed around the drainage pipes should consist of a uniformly graded coarse aggregate satisfying the size requirements of AASHTO M-43, Size No. 57. Non-woven geotextile should be placed around the aggregate filter.

The design and construction of any subdrainage system is not completely foolproof, and local in-operation of the system may occur due to various causes. Clean-outs should be spaced for efficient maintenance with one clean-outs at a maximum spacing of 250-ft. The system may require flushing at periodic intervals if silt or clay size particles penetrate into the slotted pipe.

6.0 CONSTRUCTION CONSIDERATIONS

The contractor should exercise care during excavation for spread footings so that as little disturbance as possible occurs at the foundation level. The contractor may have to use forms to stabilize the sides of the excavation, when excavating into the lightweight aggregate fills. The contractor should carefully clean loose or soft soils from the bottom of the excavation or recompact any loose light weight aggregate fill before placing concrete.

Dewatering of the Grannis Ditch will be required for placement of lightweight aggregate fills below the water levels. The dewatering system should be of sufficient size and capacity to lower the groundwater below the bottom of the Grannis Ditch and to allow work to be installed in a dry condition (no standing water when placing lightweight aggregate fills); and in a manner that maintains stability of the subgrade soils. The contractor should be responsible for final design of the dewatering system, including the sump depth, pump spacing, and sequence of excavation and dewatering.

7.0 GENERAL

This addendum has been prepared to aid in the evaluation of this specific site and to assist in the design and construction of the new backland asphalt pavement. This addendum should only be used in conjunction with our Geotechnical Engineering Report dated March 14, 2018; and the project contract documents. Please refer to our GER for additional recommendations, conclusions, and limitations of our studies.

We have endeavored to complete the services identified herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions as this project. No other representation, express or implied, is included or intended, and no warranty or guarantee is included or intended in this report, or other instrument of service.

We appreciate the opportunity to be of service for this project. Please call us if you have any questions regarding this addendum.

SCHNABEL ENGINEERING, LLC

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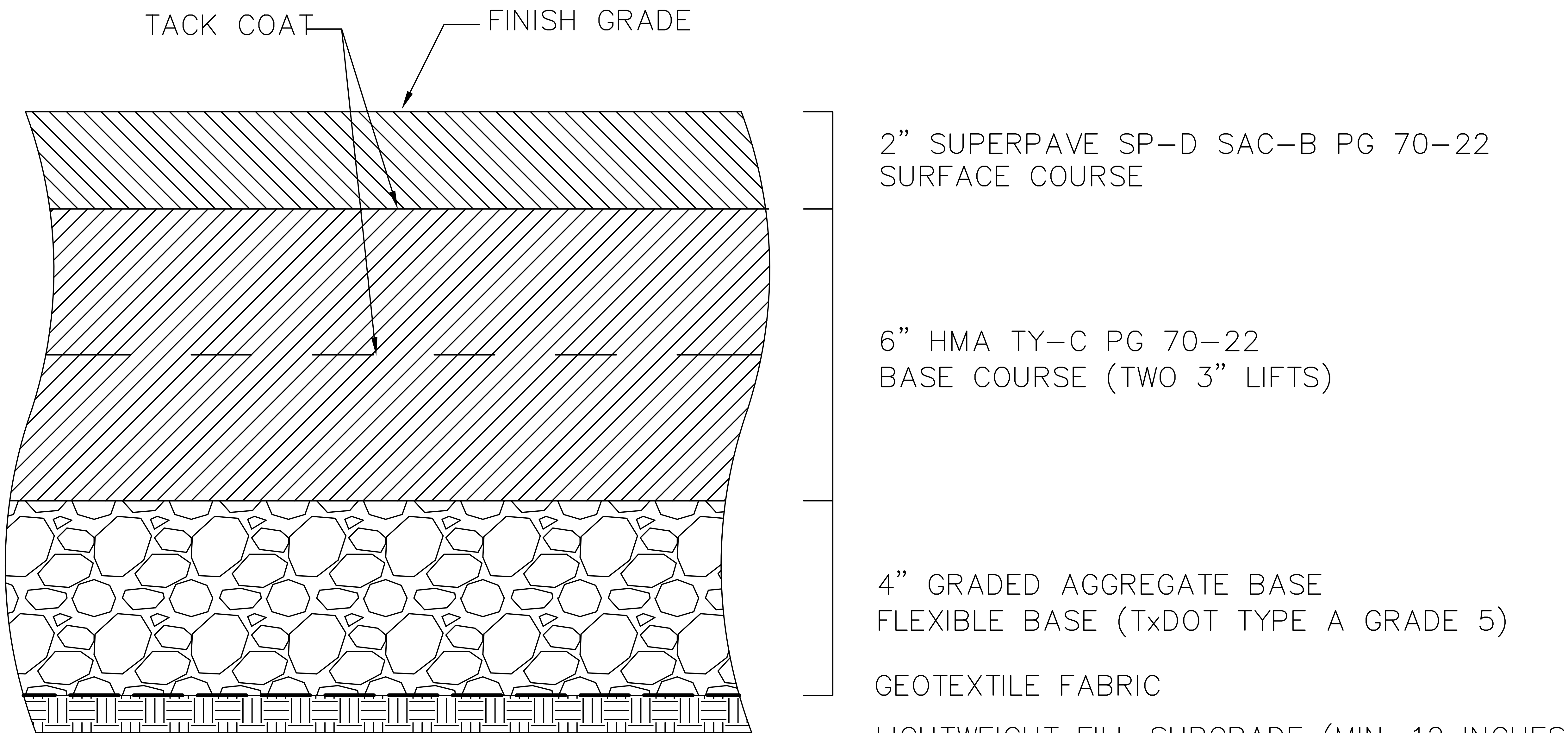
FIGURES



TYPICAL BACKLAND PAVEMENT SECTION
(NTS)

NOTES:
1) PLACE GEOTEXTILE FABRIC ON COMPACTED LIGHTWEIGHT FILL SUBGRADE.
2) TACK COAT REQUIRED AT ALL VERTICAL JOINTS BETWEEN SURFACE AND BASE COURSES.
3) BITUMINOUS JOINT SEALER TO BE APPLIED ALONG THE LONGITUDINAL JOINT AT THE SURFACE BETWEEN EXISTING AND NEW PAVEMENT.

Schnabel ENGINEERING	PORT OF PORT ARTHUR BERTH 5 BACKLAND PAVEMENT PORT ARTHUR, TEXAS PROJECT 17C13187.00	HEAVY DUTY BITUMINOUS PAVEMENT SECTION