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BUREAU OF INDIAN AFFAIRS MATERIALS GROUP

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March 30, 2016

MATERIALS DESIGN MEMORANDUM

REPORT #: N00370_N12(19-4)2&4_001
REPORT TYPE: **INITIAL**

TO: ALBERT LEE, DESIGN ENGINEER
HAROLD RILEY, PLANNING AND DESIGN CHIEF

FROM: CHRISTOPHER BECENTI
MATERIALS DESIGN SECTION ENGINEER
MATERIALS GROUP

REF: N12(19-4)2&4,
RECONSTRUCTION OF EXISTING ROADWAY
STATION 38+700.000 TO 55+900.000

Project Scope

The Route N12 Priority Standing has recently been raised and is available for reconstruction in 2016. This materials design letter presents the results of the pavement design analysis performed on BIA Route N12.

BIA route N12(19-4)2&4 project section is approximately 17.2-kilometer long and located in the Chinle Agency. The project is location between the Wheatfields Lake and Tsaile N12/N64 intersection and is situated completely within Navajo Nation trust land. The Project Scope plans on reconstructing the pavement, widening the roadway, and adding aggregate shoulders. There are two existing bridges within the project limits and will also undergo remediation as dictated by the Bridge Section.

The road was initially constructed under N12(19) in 1964, and subsequently had 3 additional projects. Project N12(19) scope of work provided for Grade, Drain, and Surface (see as-built table). Project N12(19-1) scope of work provided for Type 3 Seal Coat (see as-built table). Project N12(19-2) scope of work provided for localized repair with Cement Treated Base (CTB (see as-built table). Project N12(19-3) scope of work provided for full Length overlay (see as-built table).

Under 2015 Safety Project N12(19) the Cement Treated Base was uncovered for cut section 3. It was found to be intact will little to no issues, and the resultant decision was to leave it in place.

The design memorandum will recommend four (4) typical sections for the mainline alignment, to utilize the existing CTB, address cut sections below the existing roadway, and Bridge detours.

As-built table of N12 Station 38+700 to 55+900

Metric						N12(19-1)	N12(19-3)	
Begin	End	sub base	CTB	base	roadmix	Type 3 seal	overlay	
38+700.000	38+754.759	228.6		152	76.2	x	50.8	N12(19)
38+754.759	38+907.769	482.6	203		76.2	x	50.8	N12(19-2)
38+907.769	40+259.557	228.6		152	76.2	x	50.8	N12(19)
40+259.557	40+442.437	482.6	203		76.2	x	50.8	N12(19-2)
40+442.437	40+686.277	228.6		152	76.2	x	50.8	N12(19)
40+686.277	41+082.517	482.6	203		76.2	x	50.8	N12(19-2)
41+082.517	42+149.317	228.6		152	76.2	x	50.8	N12(19)
42+149.317	42+423.637	482.6	203		76.2	x	50.8	N12(19-2)
42+423.637	42+560.797	228.6		152	76.2	x	50.8	N12(19)
42+560.797	42+652.237	482.6	203		76.2	x	50.8	N12(19-2)
42+652.237	43+856.197	228.6		152	76.2	x	50.8	N12(19)
43+856.197	45+258.277	152.4		152	76.2	x	50.8	N12(19)
45+258.277	45+502.117	482.6	203		76.2	x	50.8	N12(19-2)
45+502.117	46+081.237	482.6	203		76.2	x	50.8	N12(19-2)
46+081.237	51+750.517	228.6		152	76.2	x	50.8	N12(19)
51+750.517	52+649.677	152.4		152	76.2	x	50.8	N12(19)
52+649.677	55+651.957	0		152	76.2	x	50.8	N12(19)
55+651.957	55+900.000	152.4		152	76.2	x	50.8	N12(19)

DESIGN ANALYSIS AND DISCUSSIONS

N12(19-4)2&4-Mainline Project

In designing the roadway pavement section, the design traffic was based on the existing traffic provided through the Navajo Region Roads Traffic Volume database, projected for a design period of 20 years. AMEC consulting provided a geotechnical investigation/report for the project delivering the following information by boring logs of the existing layers of the Roadway prism. The information provided included the location of borings, thickness of the layers, Hydrochloric acid reaction, blow count, and visual soil classification.

Due to the brevity of the geotechnical report and lack of surface recommendation, I have used the NM DOT R value estimation to determine subgrade strength in cut locations. I have used a combination ASTM D6951, California Bearing Ratio (CBR) – Dynamic Cone Penetration (DCP) correlations, and ASTM 1856-64, Standard Penetration Test (SPT)-Dynamic Cone Penetration (DCP) correlations, to informally estimate in situ strength of the existing pavement typical section.

Table Future Simple ESAL (Equivalent Single Axle Load) Calculation below shows the parameters used for the calculation of the N12(19-4)2&4 ESAL.

Future Simple ESAL Calculation

Parameter	**N12(19-4)2&4**	
	Mainline	**Detour**
Performance Period(years)	20	2
Two-Way Traffic (ADT)	1,972	1,972
Number of Lanes in Design Direction	1	1
Percent of All Trucks in Design Lane	100%	100%
Percent Trucks in Design Direction	50%	50%
Percent Heavy Trucks(of ADT) FHWA Class 5 or greater	9%	9%
Average Initial Truck Factor (ESALs/Truck)	1.12	1.12
Annual Truck Factor Growth Rate	0%	0%
Annual Truck Volume Growth Rate	2%	2%
Growth	Compound	Compound
Total Calculated Cumulative ESALs	882,037	73,330

Table Structural Number for Future Traffic below shows the parameters used for the design of the reconstructed structural section for the Mainline Project Section of N12(19-4)2&4.

Structural Number for Future Traffic

Parameter	**N12(19-4)2&4**			
	Mainline	Existing CTB	Cut Locations	Detour
Typical section number	1	2	3	4
Design Life (years)	20	20	20	2
18-Kip ESALs (One Way)	882,037	882,037	882,037	73,330
Initial Serviceability (Po)	4.2	4.2	4.2	4.2
Terminal Serviceability (Pt)	2.0	2.0	2.0	2.0
Reliability Level	70%	70%	70%	65%
Overall Standard Deviation (So)	0.45	0.45	0.45	0.45
RoadBed Soil Resilient Modulus	45,160 KPA	45,160 KPA	37,507 KPA	45,505 KPA
Required SN (per AASHTO 1993 Guide)	77 mm	77 mm	82 mm	51 mm

Future Typical Section N12(19-4)2&4

Begin	End	Future Typical Section	Length	Location
38+700.000	38+754.759	Typical Section 1	54.759	Mainline
38+754.759	38+907.769	Typical Section 2	153.01	Mainline
38+907.769	40+259.557	Typical Section 1	1351.788	Mainline
40+259.557	40+442.437	Typical Section 2	182.88	Mainline
40+442.437	41+200	Typical Section 3	757.563	Mainline
41+200	42+149.317	Typical Section 1	949.317	Mainline
42+149.317	42+423.637	Typical Section 2	274.32	Mainline
42+423.637	42+560.797	Typical Section 1	137.16	Mainline
42+560.797	42+652.237	Typical Section 2	91.44	Mainline
42+652.237	44+540	Typical Section 1	1887.763	Mainline
44+540	45+000	Typical Section 3	460	Mainline
45+000	45+258.277	Typical Section 1	258.277	Mainline
45+258.277	45+502.117	Typical Section 3	243.84	Mainline
45+502.117	46+081.237	Typical Section 3	579.12	Mainline
46+081.237	55+900.000	Typical Section 1	9818.763	Mainline

Typical Section1		
Description	Drainage Coef	Thickness (mm)
HACP 402	1	63.5
HACP 402 w tack	1	63.5
CRAB w prime	1	203
Scarify/compact Subgrade per FP-14		
	total	330

Typical Section 2		
Description	Drainage Coef	Thickness (mm)
HACP 402	1	63.5
HACP 402 w tack	1	63.5
Prime existing CTB	1	
Inspect existing CTB		
	total	127

Typical Section 3		
Description	Drainage Coef	Thickness (mm)
HACP 402	1	63.5
HACP 402 w tack	1	63.5
CRAB w Prime	0.9	203
EN-1 Stabilized	0.7	304
Scarify/Compact Subgrade per FP-14		
	total	635

Station						
Main	Detour	Main	Detour	Future Typical	Length	Location
39+060.000	0+000	39+579.265	0+789.561	Typical Section 4	789.561	Detour
49+610.000	0+000	49+930.000	0+343.486	Typical Section 4	343.486	Detour

Typical Section 4		
Description	Drainage Coef	Thickness (mm)
HACP 402	1	63.5
Aggregate Base Course w Prime	1	177.8
Scarify/Compact Subgrade per FP-14		
	total	241

SECTION I – FLAT BOTTOM BORROW DITCH & SUBGRADE ACCEPTANCE

Subgrade construction control R-value of 15 has been selected for segments within typical section 1 and 4. It is recommended that soil within 1 meter of the final subgrade elevation meet this construction control value, thereby all soils not meeting this value are considered unsuitable soils for strength. Inspection can use the NM DOT Method for R value estimation (see attached document).

The soil within 1 meter of the final subgrade elevation inside segments requiring stabilization with EN-1 in the roadway prism shall have a minimum Plasticity Index PI of 12. Soil in these locations should not be used for borrow or subgrade due to possible expansion characteristics.

New Mexico Department of Transportation

Estimated R-Value Chart (60% Risk)

Effective Date: 1/1/06

NOTE: The estimated R-Values shown on this chart have a 60% chance of being equal to or greater than the indicated estimated R-Value and a 40% chance of being equal to or less than the indicated estimated R-Value. If there is reason to believe that the actual laboratory R-Value would be higher than what this chart estimates, then a representative sample of that material should be tested using AASHTO T 190 by either the Department's State Materials Bureau or at an approved laboratory that is certified by the Department's State Materials Bureau to perform AASHTO T 190.

Plasticity Index	AASHTO Soils Classification											
	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-4	A-5	A-6	A-7-5	A-7-6
0	72	69	55	No Correlations Presently Exists			No Correlations Presently Exists	46	46			
1	72	67	53					43	43			
2	71	65	50					41	40			
3	71	63	48					38	36			
4	71	62	45					36	33			
5	70	60	43					33	30			
6	70	58	40					31	27			
7			38					28	24			
8			35					26	21			
9			33					23	18			
10			30					20	15			
11					31	33				11	9	7
12					30	32				11	9	7
13					29	31				11	9	7
14					28	29				10	9	6
15					27	28				10	9	6
16					26	27				10	8	6
17					25	26				9	8	6
18					24	25				9	8	6
19					23	23				9	8	6
20					22	22				8	8	6
21					21	21				8	7	6
22					20	20				7	7	6
23					19	19				7	7	6
24					18	17				7	7	6
25					17	16				6	7	6
26					16	15				6	6	6
27					15	14				6	6	6
28					14	13				5	6	6
29					13	11				5	6	6
30					12	10				< 5	6	6
31					11	9				< 5	6	5
32					10	8				< 5	5	5
33					9	7				< 5	5	5
34					8	5				< 5	5	5
35					7	< 5				< 5	5	5
36					6	< 5				< 5	5	5
37					5	< 5				< 5	< 5	5
38					< 5	< 5				< 5	< 5	5
39					< 5	< 5				< 5	< 5	5
40					< 5	< 5				< 5	< 5	5

The selected Earthwork Factor of 15% shrink was based from published typical values.

Off-site borrow shall meet the requirements set in the FP-14 704.06 unclassified borrow.

SECTION II - SUBBASES AND BASES

Item 1 –Section 408-Cold Recycle Asphalt Base (CRAB) Course

The existing 127 mm of Hot Asphaltic Concrete Pavement will be milled to a gradation passing the 37.5-mm Sieve and combined with Existing Aggregate Base Course. If additional Aggregate Base Course is needed please see Item 2 for gradation of virgin Aggregate Base. The resultant material will be reclaimed and used as the Base of the roadway.

Item 2 – EN-1 Stabilization

See Section 213 as revised.

Item 3 – Existing Cement Treated Base

Inspect Cement Treated Base for damage .Intact CTB locations shall remain in place. Localized damaged locations can be replaced with CTB, see section 302. Larger locations contact Materials Engineer.

Item 4 - AGGREGATE BASE COURSE (ALTERED GRADATION)

The Aggregate Base Course shall be an altered gradation, and shall be as specified in SUPPLEMENTAL Section 703.05 of the Specifications. To be mixed with the CRAB as needed at specified thickness

SECTION 703 - AGGREGATE

703.05 Subbase, Base, and Surface Course Aggregate

The Section (b) of this section is superseded with the following:

b) Subbase or base aggregate
   1) Gradation Table 703-2

Table 703-2
Aggregate Base Gradation Special

Sieve Size	Percent by Mass Passing Designated Sieve (AASHTO T27 & T11)
37.5 mm	100
25 mm	80-100
19 mm	65-80
9.5 mm	40-65

4.75 mm	30-50
425 µm	8-30
75 µm	2-12

SECTION III - SURFACE TREATMENTS AND PAVEMENTS

Item 1 - PRIME COAT

The prime coat shall be as specified in Section 411 of the Standard Specifications and supplemental specification for Penetrating Emulsified Prime (PEP).

Item 2 - TACK COAT

A tack coat shall be applied as necessary to provide proper bonding prior to the placement of each lift of AC over an underlying bituminous surface. The tack coat shall be as specified in Section 412 of the Standard and Supplemental Specifications.

Item 3 - ASPHALTIC CONCRETE 402 Class B, Grade B –

The asphaltic concrete shall be as specified in section 402 of the Standard and Supplemental Specifications. For estimating purposes the unit weight of the bituminous mix is 2430 kilograms per cubic meter, and the asphalt is 6.0%. The asphalt type shall be PG 64-22.

BASIS OF ESTIMATED QUANTITIES				
Item No.	Description	Grade	Unit Weight	Application
21301-4000	RoadBond EN-1			Mix Ratio 1:200; EN-1:Water
30103-2000	Untreated Aggregate Base Course	Special (703-2)	2164 kg/m^3	152 mm – mainline, 152mm turnout
40201-0500	Hot Asphaltic Concrete Pavement, Class B	B	2324 kg/m^3	Main Roadway and Turnouts 76mm (38 Lifts)
40502-0800	Asphalt Cement	PG 64-22		6.0% by Wt. of Total Weight of Mixture
41101-5000	Prime Coat	PEP	993 L/t	1.36 L/m^2 Application rate
41201-1000	Asphalt Emulsion Tack Coat	SS-1	1.001 l/kg	0.23 L/m^2 Application rate

SECTION IV – DRAINAGE PIPE

No recommendation, No soil test in Geotechnical report

SECTION V – GEOTECHNICAL REPORT AVAILABILITY

The General Notes in the Plan set referring to Geotechnical Investigation Report, shall be accompanied with "for informational purpose only"

3-30-16

Harold Riley
BIA NRDOT Planning and Design Chief

Christopher Becenti P. E.
BIA NRODT Assistant Materials Engineer

1997 AASHTO Pavement Design

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Flexible Structural Design Module

Station 40+450 to 41+800 R value of 8
Station 44+540 to 45+000 R value of 10

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	882,037
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	70 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	37,507.4944 kPa
Stage Construction	1
Calculated Design Structural Number	82 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,972
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	9 %
Average Initial Truck Factor (ESALs/truck)	1.12
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	2 %
Growth	Compound
Total Calculated Cumulative ESALs	882,037

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HACP	0.42	1	127	3.6576	53
2	CRAB	0.1	0.9	203.2	3.6576	18
3	EN-1 stabilized.	0.06	0.7	304.8	3.6576	13
Total	-	-	-	635	-	84

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Primary Project length R=10

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	882,037
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	70 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	45,160.678 kPa
Stage Construction	1
Calculated Design Structural Number	77 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,972
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	9 %
Average Initial Truck Factor (ESALs/truck)	1.12
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	2 %
Growth	Compound
Total Calculated Cumulative ESALs	882,037

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HACP	0.42	1	127	3.6576	53
2	CTb	0.15	1	203.2	3.6576	30
Total	-	-	-	330	-	84

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Flexible Structural Design Module

Primary Project length R=10

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	882,037
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	70 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	45,160.678 kPa
Stage Construction	1
Calculated Design Structural Number	77 mm

Simple ESAL Calculation

Performance Period (years)	20
Two-Way Traffic (ADT)	1,972
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	100 %
Percent Trucks in Design Direction	50 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	9 %
Average Initial Truck Factor (ESALs/truck)	1.12
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	2 %
Growth	Compound
Total Calculated Cumulative ESALs	882,037

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	HACP	0.42	1	127	3.6576	53
2	CRAB	0.12	1	203.2	3.6576	24
Total	-	-	-	330	-	78

1997 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

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Computer Software Product

Flexible Structural Design Module

Detour road

Flexible Structural Design

80-kN ESALs Over Initial Performance Period	73,330
Initial Serviceability	4.2
Terminal Serviceability	2
Reliability Level	65 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	45,505.416 kPa
Stage Construction	1
Calculated Design Structural Number	51 mm

Simple ESAL Calculation

Performance Period (years)	2
Two-Way Traffic (ADT)	1,972
Number of Lanes in Design Direction	1
Percent of All Trucks in Design Lane	50 %
Percent Trucks in Design Direction	100 %
Percent Heavy Trucks (of ADT) FHWA Class 5 or Greater	9 %
Average Initial Truck Factor (ESALs/truck)	1.12
Annual Truck Factor Growth Rate	0 %
Annual Truck Volume Growth Rate	2 %
Growth	Simple
Total Calculated Cumulative ESALs	73,330

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(mm)	Width (m)	Calculated SN (mm)
1	ABC	0.14	1	177.8	4.2672	25
2	HACP	0.44	1	63.5	3.6576	28
Total	-	-	-	241	-	53