STATE OF COLORADO

DEPARTMENT OF TRANSPORTATION
Region 6 – Materials Engineering Unit
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IM 088A-024
PCN 16628
SH088A (Federal Blvd.) over 6th Ave.

DATE: March 2, 2010

TO: **Nick Engineer's Engineer Cheng / Tony Da Man Gross**

FROM: James Chang

SUBJECT: **Pavement Design Report**

Acknowledgements

This Region 6 Materials pavement design report was developed using information from the subsurface investigation conducted by Matt McMechen, Ken Meyer, and Mark Lyubinin of Region 6 Materials and the drill crew from Staff Materials. Region 6 Materials and the Staff Soils unit conducted the required laboratory classification and testing. Bob Mero devoted countless hours to the dissection of the Valley Highway EIS, and both he and Masoud Ghaeli provided a plethora of technical and insightful editorial support. All of the above-mentioned were indispensable in the preparation of this report. Their help and hard work is greatly appreciated and is hereby acknowledged.

Contents

The following supporting calculations / pavement design are included:

Appendix 1

- Rigid Pavement Design Calculations (Using 30-year ADT / Rigid ESALs)
- Flexible Pavement Design Calculations (Using 20-year ADT / Flexible ESALs)

Appendix 2

- Tenthmile Roadway Inventory Survey
- Pavement History
- Note: The Preliminary Pavement / Subsurface Investigation is included under separate cover due to Staff Soils document security settings.

Preliminary Pavement / Subsurface Investigation

The preliminary pavement / subsurface soil investigation was comprised of 12 bore holes: three on SH 088A, one each on the ramps west of Federal Boulevard, two were taken along the proposed southeast ramp alignment, two on 5th Avenue, one on the eastbound SH 6 Ramp at Bryant Street , and one each on the shoulder of westbound and eastbound 6th Avenue. The borehole locations are shown below in Figure 1. Arrows are used to denote the borehole locations. Orange arrows indicate proposed locations that were successfully bored while lavender arrows are new boring locations added during the course of the investigation. Red arrows denote locations where borehole samples where not successfully obtained due to right-of-way, topographic, utility, safety, or jurisdictional restrictions. For example, the two bore hole locations to the west of Barnum Park along Federal Boulevard were not obtained because of time constraints associated with obtaining the necessary clearances. They were originally identified as being within the City and County of Denver's jurisdiction; however, Region 6 Materials was informed close to the boring dates that these locations were actually in the Parks and Rec Division's jurisdiction due to the presence of trees. The borehole on the northeast ramp was unobtainable due to the extreme side slope and the narrowness of the existing ramp. Detailed results of the boring are available as a separate attachment.

The investigation showed that the existing pavement on Federal Blvd. is comprised of between 11" to 14" of hot mix asphalt (HMA) over A-6 (7) soil. The ramps have 11" of HMA and are underlain by the same material. Fifth Avenue also has an asphalt surface (5" to 8"); however, it is underlain by a foot and a half of A-1-b(0) granular material followed by 2 feet of A-6 material. Borehole 25A (Bryant Street) was similar to 5th Avenue. HMA was underlain by A-1-b(0) material; however, at Bryant Street this coarse material is underlain by A-7-6(23) material. The shoulders on 6th Avenue were cored to determine viability in handling detour traffic. The HMA thickness was found to be 14" in the eastbound direction and 13" in the westbound direction.

The subsurface investigation shows that the in-situ soils are A-1-b, A-6, and A-7-6 with various group numbers. The A-1-b soil is generally considered good to excellent soil subgrade material. Both the A-6 and A-7-6 soils are fair to poor subgrade materials. These soils are susceptible to volume changes and strength changes. The plastic indices, an indication of swell potential, ranged from 22 to 23 % for the A-6 soils and 26 % to 33 % for the A-7-6 material. The plastic indices indicate that the majority of soils at this location are susceptible to swelling. R-value testing was conducted to determine the soil in-situ strength as shown below in Table 1.

Location	Soil Type	M_r (psi)	R-value
Various Locations	A-1-b(0)	21,500	65
Various Locations	A-6 (7), A-6 (8)	3,929	13
Borehole 8	A-7-6(14)	4,334	16
Borehole 25	A-7-6 (23)	3,803	12

Table 1.0 Soil Resilient Modulus and R-values.

At the two locations tested, water-soluble sulfate levels were not detected at any of the locations; however, it may be prudent to assume a Class 2 severity of potential exposure class since the proposed pavement might be exposed to sulfate from other sources such as surface runoff, etc.

Subgrade Preparation and Embankment Material

The subsurface investigation shows that the plasticity index (PI) of the in-situ soil is in the 20 to 30 range, and PI's such as these are an indication that the soil may have swell potential. Based on recommendations found in the 2010 Pavement Design Manual, the depth of treatment for PI's between 10 – 20 is two feet. For PI's from 20-30, a depth of treatment of 3 feet is required. There does not appear to be any evidence of swelling soil damage on Federal Boulevard. This could indicate that while the existing soil has a highly expansive nature, the moisture content and compactive effort specified during the original construction was high enough to minimize swell.

Excavating and exposing the subgrade soil will be problematic. If the soil is allowed to dry out during construction, the swell potential is greatly increased. Since concrete pavement is more sensitive to swelling soil damage, chemical stabilization is one option. Stabilization with lime or fly ash is an alternative but may not be feasible on this project. The risk with lime treatment is three-fold. Besides the nuisance to nearby businesses during construction, lime is almost never mixed evenly. Thus, certain areas will have more resistance than other locations. This can, for the most part, be addressed by a very stringent QC/QA plan which has inherent risk. Also, the possibility that the lime-treated surface will encounter sulfates is high. The sulfates could be transported via surface runoff (irrigation, etc) and would access the subgrade material through spaces between the PCCP slabs via seals that might have shifted or be out of place. This subsequent interaction of sulfates with lime could induce swelling.

The use of fly ash (cement-treated) base on this project also may not be feasible because its effectiveness is dependent on the in-situ soils. If the in-situ soils were sandy / silty material with low plasticity, fly ash would be a viable option. The pavement design guide recommends fly ash if the PI (plasticity index) is less than 20. However, a large proportion of the on-site soils are A-6 and A-7-6 materials with PI's between 20 and 30.

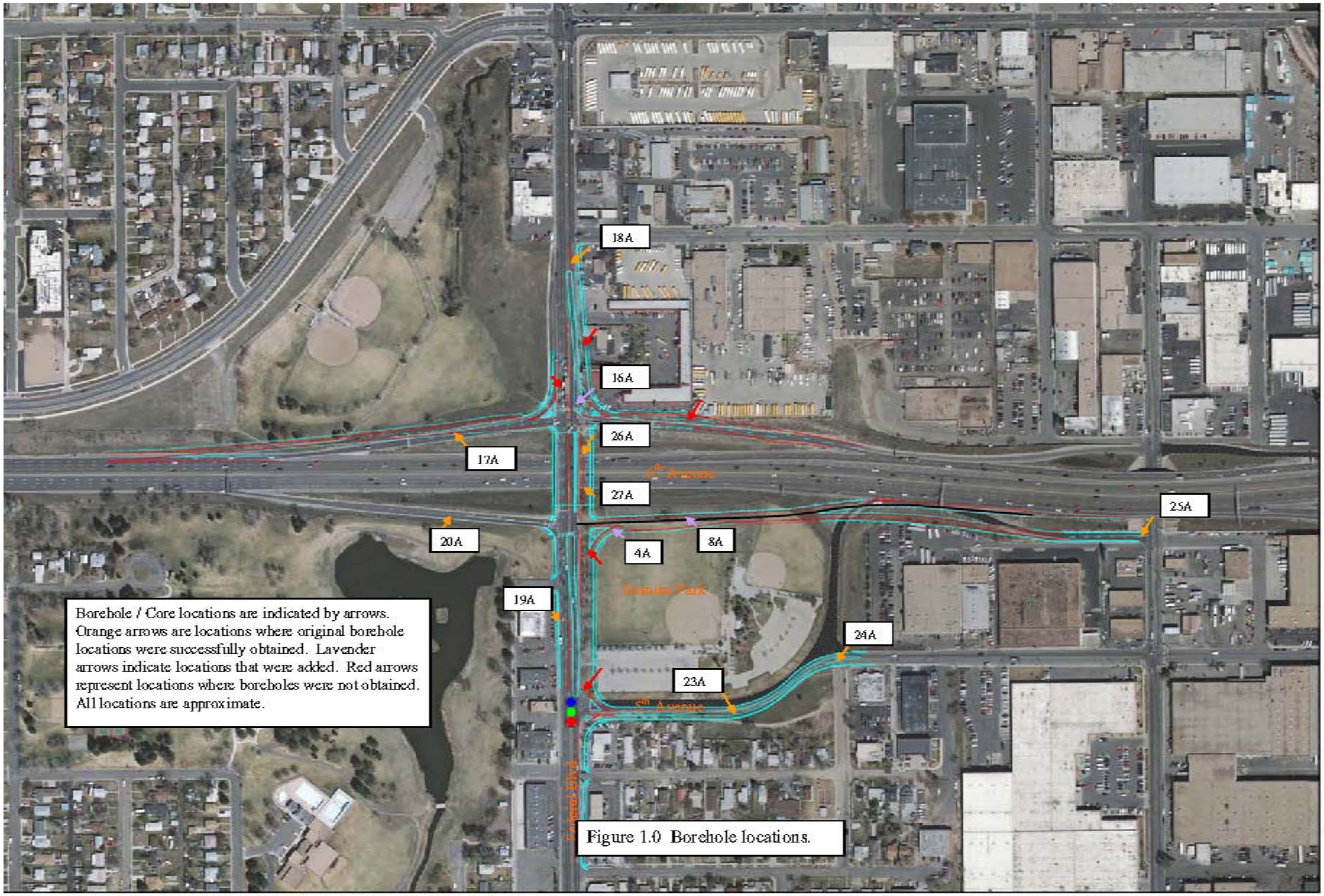

Figure 1.0 Borehole locations.

A possible remedy would be to add fly ash at higher percentages; however, adding fly ash at levels greater than 25 % could lead to density and durability issues and is strongly discouraged. Hence, mitigation with fly ash is also eliminated.

Moisture conditioning is recommended in cut areas and in areas where the preference is to not disturb the existing soil (such as on Federal Boulevard and at locations where the removing and replacing the existing soil is prohibitive) since there is a lack of evidence of swelling soil damage. Region 6 Materials recommends that the existing soil underneath the proposed ABC Class 6[1] be moisture conditioned and recompacted to + 2 % wet of optimum, following section 203 of the 2005 CDOT Standard Specifications for Road and Bridge Construction, to a depth of 1 foot. In areas where there are potential utility conflicts, this may be reduced to 6 inches. In all cases, the prepared subgrade should be proof rolled to determine if any soft spots are present. Any soft spots should be removed and recompacted and proof rolled again. If this does not eliminate the soft spot, the soil should be excavated and replaced with minimum R-value 20 material and recompacted and proof rolled until satisfactory. If this does not ameliorate the soft soil conditions, the use of a Class I geotextile will then be required.

Soils with a minimum R-value of 20 should be used in roadway prism areas incorporating embankment. The material within the top four feet should be nonswelling and compacted to + 2 % wet of optimum where nonswelling is defined as a percent swell less than or equal to 1 when tested with a surcharge of 200 psf. Embankment more than four feet below bottom of the proposed ABC Class 6 should be compacted to + /- 2 % of optimum at a minimum relative compaction of 95 % and does not have the swell requirement. All embankment should be constructed in lifts not exceeding 8-inches and have a maximum dry density not less than 90 pounds per cubic foot. Per CDOT Typical Section Figures 4-1 thorough 4-5, the above treatments should extend to the sideslope in areas with unprotected slope. In areas with curb and gutter, the treatment should extend for a minimum distance of 12" beyond the back face of the gutter, if possible. This should be shown in the plan set typical sections.

Because the on-site soils are highly plastic, it is very possible that unstable soils will be encountered. Thus, it is recommended that a representative of Staff Soils be invited to monitor the preparation of subgrade, thereby minimizing the likelihood that new pavement will be constructed on unstable soil.

Pavement Designs

Both full-depth concrete pavement and full-depth flexible pavement designs were conducted. To match the pavement from the proposed Federal Boulevard: Alameda Avenue to 5th Avenue project, the pavement for this section of SH 088A was designed in concrete while ramps and side streets were designed in flexible pavement to replace in-kind the existing pavement material.

The Annual Average Daily Traffic (AADT) and 18-kip Equivalent Single Axle Load (ESAL) projections for the Portland cement concrete pavement (PCCP) were obtained from the CDOT DTD website using the 2008 counts (circa March 2009) for SH 088A (Federal Boulevard) from MP 0 to MP 1.36 using 2015 as the base year, a 30-year design period, and 6 travel lanes. For the flexible pavement designs, 2015 was also used as the base year; however, a design period of 20-years was used. Facility-specific estimates of AADT and flexible 18-kip ESALs for the facilities were obtained using the Valley Highway, Logan to 6th Avenue Environmental Impact Statement (EIS) where possible. The long, tedious task of extracting data from the EIS, using the information to develop the AADT and flexible 18-kip ESALs, and packaging the resulting results in a useable format for the ramps, the slip ramp, and for 5th Avenue was undertaken by Bob Mero. The design hour volume was assumed to be 9 % of the AADT, and design lane factors from the 2010 Pavement Design Manual were used. For facilities with varying lane configurations, the pavement design incorporated the AADT and 18-kip ESALs corresponding to the lesser of the number of lanes. The AADT and flexible 18-kip ESALs for the local streets not addressed in the EIS were developed using traffic count data for 1st Avenue circa 2008 provided by the City and County of Denver for project STU C010-068 (13810) which will construct Federal Boulevard from Alameda Avenue to just south of 5th Ave and assuming that resulting traffic volume and loading is ½ of that on 1st Avenue (See Table 2). The AADT and 18-kip ESALs corresponding to the midpoint year of the design period was used for all designs.

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[1] The use of a 6-inch base of aggregate base course Class 6 to minimize future pavement distress caused by fines migration and pumping, and moisture conditioning and to provide a stable base yet gradable base is recommended.

Location	# Lanes	Design Lane Factor (DLF)	Design Hour Volume at Midpoint Year (DHV 2025)	Average Annual Daily Traffic (AADT)	% Medium Trucks (% MT)	% Heavy Trucks (% HT)	18-kip ESALs
Federal Blvd.	6	0.3	N/A	55,412	3.8	1.3	5,790,899
6th Avenue	6	0.3	N/A	147,436	2.6	1.3	7,127,707
US6 @ SH88	6	0.3	12,430	138,111	2.6	1.3	7,104,259
US6 @ SE Ramp	4	0.3	8,045	89,389	1.8	0.9	3,363,968
SH88	6	0.3	5,870	65,222	3.8	1.4	3,931,436
SH88 NB	3	0.45	2,840	31,556	3.8	1.4	2,853,138
SH88 SB	3	0.45	3,030	33,667	3.8	1.4	3,044,017
NE Ramp	1	1	990	11,000	3	1	1,703,966
	2	0.6					1,022,380
NW Ramp	1	1	1,080	12,000	3	1	1,858,872
	2	0.6					1,115,323
SW Ramp	1	1	460	5,111	3	1	791,742
	2	0.6					475,045
SE Ramp W	1	1	1,125	12,500	3	1	1,936,325
	2	0.6					1,161,795
SE Ramp E	1	1	1,100	12,222	3	1	1,893,296
	2	0.6					1,135,977
5th Ave.	1	1	240	2,667	3	1	413,083
	2	0.6					247,850
Slip Ramp	1	1	25	278	3	1	43,029
Side Streets	2	0.6	N/A	3,522	4.9	1.1	403,390

Table 2.0 AADT and Flexible 18-kip ESALs. AADT and 18-kip ESALs developed from the Valley Highway EIS by Bob Mero are shown in green. 18-kip ESALs used in the pavement designs are shown in baby blue.

The 30-year rigid pavement design was completed using the 1998 AASHTO Supplement. The design assumes that the pavement will be underlain by 6 inches of ABC Class 6 and that 15 foot transverse joint spacing will be utilized. Since the in-site subgrade R-values ranged from 12 to 16, a conservative R-value of 10, corresponding to a modulus of subgrade reaction (k) of 71 psi, was utilized. After the thickness was calculated, ¼ inch was added and the resulting thickness was then rounded up to the nearest ½ inch per the CDOT Pavement Design Manual to yield a thickness of 9.5 inches. The next phase of the design checked for faulting and corner breaks using "site-specific" climate data. Climate data from STU C-1-068 was utilized with the approximate intersection of Federal Blvd. and 1st Avenue (MP 1.5, longitude 105.035, latitude 39.7187) representing the project geographic location. LTPPBind selected weather stations Wheatridge 2 (CO8995) and Lakewood (CO7862) as the closest weather stations (Figure 2) . Data for Wheatridge 2, the closer of the two weather stations, was used for the checks. For the faulting check, the default value of 0.06 inches (joint spacing less than 25 feet) was used instead of the 0.08 inch value recommended in the CDOT Pavement Design Manual. The PCCP design passed the faulting and corner break checks.[2] The 1998 AASHTO Supplement output is included in Appendix 1.

[2] The corner break check utilized graphs of stress at the top of the slab versus negative temperature differential. However, since graphs are not available for ABC Class 6 with an assumed 20,000 psi elastic modulus, the stress versus negative temperature differential graphs for a 6 inch base with an elastic modulus of 25,000 psi were used in the design. Before proceeding with the design, the validity of using the 25,000 psi graphs was investigated by performing a linear regression on the 25,000 psi graphs and the 1,000,000 psi graphs using a 0 degree negative temperature differential and extrapolating the corresponding 20,000 psi value. At the given negative temperature differential, the difference in stress for 20,000 psi base and the value for the 25,000 psi base was less than 1 psi. Thus, the use of the 25,000 psi graphs to determine the stress at the top of the slabs was deemed reasonable.

Full-depth flexible pavements were designed using DARWin Version 3.01.005 by AASHTOWare with an R-value of 10 (M_r = 3,025 psi) and incorporating 6” of aggregate base course class 6 (ABC Class 6). The resulting required thicknesses (rounded to the nearest ¼”) and the final specified are presented in Table 3. Like those from the AASHTO 1998 Supplement, all DARWin output is included in Appendix 1. LTPPBind was then used to determine the binder required. As shown in Figure 3, climate data from the weather stations was utilized by LTPPBind to select the appropriate binder. LTPPBind shows that PG 70-28 binder is sufficient for the top lift of HMA; however, the more readily available PG 76-28 binder is recommended. Lower lifts may utilize PG 64-22 binder.

Five Closest Weather Stations For Latitude/Longitude= 39.718/105.035

General	A=5 km	B=9 km	C=12 km	D=15 km	E=17 km
Station ID	✓CO8995	✓CO4762	✗CO5056	✗CO2220	✗CO1547
County/District	jefferson	jefferson	arapahoe	denver	arapahoe
Weather Station	wheat ridge 2	lakewood	littleton	denver stapleto	cherry creek da
Elevation, m	1548	1597	1504	1497	1600
Latitude, Longitude	39.75 ,105.08	39.75 ,105.13	39.62 ,105.02	39.77 ,104.87	39.65 ,104.85
Last Year Data Available	1997	1997	1993	1997	1997
Air Temperature	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)	Mean (Std, N)
High Temperature	34.8 (14,16)	33.5 (13,35)	33.2 (14,15)	34.7 (13,35)	35.9 (13,33)
Low Temperature	-24.5 (41,17)	-23.9 (36,35)	-25.9 (38,15)	-24.3 (34,35)	-25.6 (34,30)
Low Temperature Drop	31.3 (22,17)	31.5 (25,35)	29.5 (38,15)	29.8 (28,35)	34.5 (37,30)
Degree-Days > 10C	2988 (165,16)	2708 (168,35)	2717 (142,15)	2910 (187,35)	3063 (205,33)
PG	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.	High Low Rel.
Pavement Temperature, C	56.5 -16.8	54.1 -16.3	54.2 -17.7	55.8 -16.6	57.1 -17.5
50% Reliability PG	58-22 (91,92)	58-22 (98,95)	58-22 (98,89)	58-22 (97,95)	58-22 (79,91)
>50% Reliability PG	64-22 (98,92)	58-28 (98,98)	58-28 (98,98)	58-28 (97,98)	64-22 (98,91)
=	64-28 (98,98)			64-28 (98,98)	64-28 (98,98)
=					
=					
=					

Figure 2. LTPPBind output for closest weather stations.

PG Binder Selection

Parameter	A=5 km	B=9 km	C=12 km	D=15 km	E=17 km
Station ID	✓CO8995	✓CO4762	✗CO5056	✗CO2220	✗CO1547
Elevation, m	5077	5239	4933	4910	5246
Degree-Days >10 C	2988	2708	2717	2910	3063
Low Air Temperature, C	-24.5	-23.9	-25.9	-24.3	-25.6
Low Air Temp. Std Dev	4.1	3.6	3.8	3.4	3.4

Input Data

Latitude, Degree	39.72	Lowest Yearly Air Temperature, C	-24.2
Yearly Degree-Days>10 Deg.C	2848	Low Air Temp. Standard Dev., Deg C	3.9

Temperature Adjustments

Base HT PG	58
Desired Reliability, %	98
Depth of Layer, mm	0

Traffic Adjustments for HT

Traffic Loading	Traffic Speed: Fast	Slow
Up to 3 M. ESAL	0.0	2.7
3 to 10 M. ESAL	7.1	9.5
10 to 30 M. ESAL	12.3	14.5
Above 30 M. ESAL	14.5	16.6

PG Temperature	HIGH	LOW
PG Temp. at 50% Reliability	55.3	-16.5
PG Temp. at Desired Reliability	57.6	-23.7
Adjustments for Traffic	9.5	
Adjustments for Depth	0.0	0.0
Adjusted PG Temperature	67.1	-23.7
Selected PG Binder Grade	70	-28

Figure 3. LTPPBind output for slow traffic between 3 and 10 million 18-kip ESALs.

The pavement analysis also examined the suitability of using the existing shoulder pavement on 6th Avenue during construction. The cores show that the shoulder pavement thickness is around 13 to 14 inches. Even with assuming a structural layer coefficient of 0.40 instead of the 0.44 used for new pavement, the analysis shows that the existing

Location	Material	Design Life (Years)	ABC Class 6 Thickness (Inches)	Calculated Thickness (inches)	Rounded Thickness (inches)	Final Thickness (inches)
Federal Blvd.	PCCP	30	6	9.18	9.5	9.5
6th Avenue	SMA / HMA	20	6	11.55	11.75	12
Northeast Ramp	SMA / HMA	20	6	9.18	9.25	9.5
Northwest Ramp	SMA / HMA	20	6	9.32	9.5	9.5
Southwest Ramp	SMA / HMA	20	6	8.05	8.25	8.5
Southeast Ramp	SMA / HMA	20	6	9.39	9.5	9.5
Slip Ramp	SMA / HMA	20	6	4.43	4.5	5
5th Avenue	HMA / HMA	20	6	7.14	7.25	7.5
Side Streets	HMA / HMA	20	6	7.09	7.25	7.5

Table 3.0 Full depth pavement designs.[3]

shoulder should be adequate to hold detour traffic for the duration of the project. However, it is possible that some of the shoulder may have much less pavement. If this pavement will be used as a future travel lane, it should be sawcut and replaced with the 12 inches of Stone Matrix Asphalt / Hot Mix Asphalt (SMA / HMA) recommended for the 6th Avenue widening.

A life cycle cost analysis is not required for this project because the cost of the pavement materials is less than $2,000,000. The Federal Boulevard pavement (minus the bridge deck) and the southeast / slip ramp were used in the calculation. The other ramp areas which will tie into the existing flexible and locations considered replace in-kind i.e. existing side street flexible pavement were not included. Using the 27,446 square yards of pavement provided by Region 6 Design, the initial pavement costs for the full depth concrete pavement is less than $2 million. With a PCCP thickness of 9.5" at a cost of $40 / square yard [4], the total pavement cost for the rigid pavement came in at $ 1,097,840 million. Thus, per the 2010 CDOT Pavement Design Manual, a life cycle cost analysis is not required.

Construction Materials and Comments

As mentioned previously, the use of geotextile may be required to address subgrade concerns while minimizing impact to existing utilities. Please include the following language regarding the inclusion of geotextile:

Geotextile installation will be required on this project. The geotextile shall meet the requirements for Geotextile Class I (Per AASHTO M 288) and be approved for stabilization and separation applications. The geotextile shall be selected from the New York State approved products list available at

https://www.nysdot.gov/divisions/engineering/technical-services/technical-services-repository/alme/pages/470-1a.html.

Instructions to access the New York State approved products list is also included in Revision of Sections 208, 420, 605, and 712 - Geosynthetics and Geotextiles. Locations requiring geotextile installation shall be as directed by the Engineer. Where geotextile installation is required, in-situ soil shall be scarified to a depth of 12 inches, or as directed by the Engineer, and then compacted, following section 203 of the 2005 CDOT Standard Specifications for Road and Bridge Construction, to 2 percent wet of optimum. As directed by the Engineer, the scarification depth may be reduced to accommodate utilities. The geotextile shall then be installed per manufacturer's recommendations. Proof rolling will be required.

[3] Region 6 recommends a functional, 2 inch mill and fill overlay on 6th Avenue using SMA (Fibers) (Asphalt) where required.

[4] The latest quarterly estimate by the Cost Estimates group placed the cost from $25 to $45 per square yard.

Please add 500 square yards of 420 Geotextile (Separator) (Class I). A corresponding general note stating how much Geotextile is required should be included. When submitting the material to Cost Estimates for project pricing, please call their attention to the kind of geotextile being used (Class I for reinforcement and separation). Also, please include Revision of Sections 208, 420, 605, and 712 - Geosynthetics and Geotextiles in the SSP index. Also, please add 120 hours of proof rolling (Item 203) and add a general note along the lines of "It is estimated that 120 hours of Proof Rolling will be required on this project." Please consult the project construction engineer to see if this amount will adequately address the project needs.

Asphalt millings meeting the requirements of ABC Class 6 Special may be substituted for ABC Class 6 underneath the PCCP pavement only. Asphalt millings can not be used as a base material underneath flexible pavements due to possible creep.

The contractor will be required to submit a pavement jointing plan for approval by Region 6 Materials and the project Engineer. Please add the following general note:

"The Contractor shall be responsible for PCCP joint design. PCCP joint design shall comply with the requirements of the CDOT Standard Plans (M & S Standard Plans) and the 2010 CDOT Pavement Design Manual. The PCCP longitudinal and transverse joint designs shall be compatible with lane and shoulder configurations. The Contractor shall submit the pavement joint design to the Engineer and the Region 6 Regional Materials Engineer for review at least 14 days prior to PCCP construction. PCCP construction shall not commence until the PCCP joint design is accepted."

Recommendations

Below please find the pavement design recommendations. Pavement design parameters for the flexible and rigid pavement alternatives are shown in Tables 4, 5, and 6. The pavement parameter tables included with this report should be incorporated into the project plans on the typical sections, on the Tabulation of Surfacing, or on separate sheet.

- SH 088A (Federal Blvd.) Full-Depth Pavement: 9.5 inches of PCCP over 6 inches of ABC Class 6. All transverse joints should utilize load transfer devices. Longitudinal joints should be tied. For the flexible pavement design, please see Tables 5 and 6.

- The nominal maximum aggregate size for the SMA shall be 0.5 inches.

- All references to SMA shall be taken to be Stone Matrix Asphalt (Fibers) (Asphalt) or SMA (Fibers) (Asphalt).

- Stone Matrix Asphalt (Fibers) (Asphalt) shall not contain any reclaimed asphalt pavement.

- Patching may be required on this project. If patching on 6th Avenue or the ramps is required, it should be to the depth of the existing / proposed pavement as directed by the Engineer. The thickness of underlying lifts should be greater than or equal to the lift directly above. The top lift should utilize SMA (Fibers) Asphalt) while lower lifts may utilize HMA (Grading S) (100) (PG 64-22).

- If patching on 5th Avenue or the side streets is required, it should be to the depth of the existing / proposed pavement as directed by the Engineer. The thickness of underlying lifts should be greater than or equal to the lift directly above. The top lift should utilize HMA (Grading SX) (100) (PG 76-28) while lower lifts may utilize HMA (Grading S) (100) (PG 64-22).

- Subgrade Preparation: The existing subgrade should be scarified and recompacted to 2 % wet of optimum following section 203 of the 2005 CDOT Standard Specifications for Road and Bridge Construction. This may be reduced to 6 inches in areas with potential utilities conflicts per the Engineer. Proof rolling will be required. After proof rolling, subgrade soft spots should be removed and replaced with minimum R-value 20 material and recompacted. If some cases Geotextile (Separator) (Class I) may be required to bridge soft soils.

- The pavement smoothness category for PCCP is Category III.
- The pavement smoothness category for flexible pavement is HRI Category I.
- The sulfate exposure class is CDOT Severity of Potential Exposure Class 2.

If you have any questions or comments about the contents of the report, feel free to e-mail me at james.chang@dot.state.co.us.

SH 088A (FEDERAL BLVD) OVER 6TH AVENUE RIGID PAVEMENT DESIGN	
DESIGN PARAMETER	**FEDERAL BLVD.**
Design life (years):	**30**
18k ESAL:	**5,790,899**
% Trucks:	**5.1**
Initial Serviceability:	**4.5**
Terminal Serviceability:	**2.5**
% Reliability:	**95**
PCC Modulus of Rupture (psi):	**650**
PCC Modulus of Elasticity (psi):	**3,400,000**
Effective Modulus of Subgrade Reaction (psi/in)	**71**
Pavement thickness (in):	**9.5 inches w/ load transfer devices***
Base Thickness (in):	**6” ABC CL 6**

* Assumes conventional 12’-wide traffic lane and tied PCC shoulder.

Table 4.0 Federal Boulevard Rigid Pavement Design

SH 088A (FEDERAL BLVD.) OVER 6TH AVENUE FLEXIBLE PAVEMENT DESIGNS				
DESIGN PARAMETER	**NE RAMP**	**NW RAMP**	**SW RAMP**	**SE RAMP**
Design life (years):	**20**	**20**	**20**	**20**
18k ESAL:	**1,703,966**	**1,858,872**	**791,742**	**1,936,325**
% Trucks:	**4**	**4**	**4**	**4**
Initial Serviceability:	**4.5**	**4.5**	**4.5**	**4.5**
Terminal Serviceability:	**2.5**	**2.5**	**2.5**	**2.5**
% Reliability:	**95**	**95**	**95**	**95**
R-Value Design:	**5**	**5**	**5**	**5**
Soil Resilient Modulus (psi):	**3,562**	**3,562**	**3,562**	**3,562**
Structural Coefficient:	**0.44**	**0.44**	**0.44**	**0.44**
Effective Pavement Modulus (psi):	**--**	**--**	**--**	**--**
Required Structural Number (in):	**4.94**	**5.00**	**4.44**	**5.03**
Drainage Coefficient:	**1.0**	**1.0**	**1.0**	**1.0**
Pavement thickness (in):	**9. 5”**	**9.5”**	**8.5”**	**9.5”**
Base thickness (in):	**6” ABC Class 6**	**6” ABC Class 6**	**6” ABC Class 6**	**6” ABC Class 6**
HMA Grading:	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**
Lift thicknesses, from bottom up (in):	**3” – 2.5” – 2”**	**3” – 2.5” – 2”**	**2.5” - 2” - 2”**	**3” – 2.5” – 2”**
SMA Grading:	**SMA (Fibers) (Asphalt)**	**SMA (Fibers) (Asphalt)**	**SMA (Fibers) (Asphalt)**	**SMA (Fibers) (Asphalt)**
Top Lift thickness (in):	**2”**	**2”**	**2”**	**2”**

Table 5.0 Federal Boulevard Flexible Pavement Design

SH 088A (FEDERAL BLVD.) OVER 6TH AVENUE FLEXIBLE PAVEMENT DESIGNS, PART DEUX				
DESIGN PARAMETER	6TH AVENUE	SLIP RAMP	5TH AVE	SIDE STREETS
Design life (years):	**20**	**20**	**20**	**20**
18k ESAL:	**7,127,707**	**43,029**	**413,083**	**403,390**
% Trucks:	**4.9**	**4**	**4**	**6**
Initial Serviceability:	**4.5**	**4.5**	**4.5**	**4.5**
Terminal Serviceability:	**2.5**	**2.5**	**2.5**	**2.5**
% Reliability:	**95**	**95**	**95**	**95**
R-Value Design:	**10**	**10**	**10**	**10**
Soil Resilient Modulus (psi):	**3,562**	**3,562**	**3,562**	**3,562**
Structural Coefficient:	**0.44**	**0.44**	**0.44**	**0.44**
Effective Pavement Modulus (psi):	**--**	**--**	**--**	**--**
Required Structural Number (in):	**5.98**	**2.85**	**4.04**	**4.02**
Drainage Coefficient:	**1.0**	**1.0**	**1.0**	**1.0**
Pavement thickness (in):	**12”**	**5”**	**7.5”**	**7.5”**
Base thickness (in):	**6” ABC Class 6**	**6” ABC Class 6**	**6” ABC Class 6**	**6” ABC Class 6**
HMA Grading:	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**	**HMA (Grading S) (100) (PG 64-22)**
Lift thicknesses, from bottom up (in):	**3” – 3” – 2” – 2”**	**3”**	**3.5” - 2”**	**3.5” - 2”**
HMA / SMA Grading:	**SMA (Fibers) (Asphalt)**	**SMA (Fibers) (Asphalt)**	**HMA (Grading SX) (100) (PG 76-28)**	**HMA (Grading SX) (100) (PG 76-28)**
Top Lift thickness (in):	**2”**	**2”**	**2”**	**2”**

Table 6.0 Federal Boulevard Flexible Pavement Design

By:

______________________________ Date: ______________
Matthew McMechen, EPS Tech III
Region 6 Materials

______________________________ Date: ______________
Bob Mero, E.I.T. III
Region 6 Materials

__________________ Date: ______________
James Chang, P.E.
Region 6 Materials

I concur: ______________________________ Date: ______________
Masoud Ghaeli, P.E. II
Region 6 Materials Engineer

Xc: Files / Region 6 Materials / Staff Materials

SH088A (Federal Blvd.) over 6th Ave.

Contents

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Rigid Pavement Design - Based on AASHTO Supplemental Guide

Reference: *LTPP DATA ANALYSIS - Phase I: Validation of Guidelines for k-Value Selection and Concrete Pavement Performance Prediction*

I. General

Agency:	CDOT
Street Address:	4670 Holly St, Unit C
City:	Denver
State:	CO, 80216-6408
Project Number:	16628
Description:	Rigid Design using R = 10 6" ABC
Location:	16628 Federal at 6th Ave

ID: Default

II. Design

Serviceability

Initial Serviceability, P1:	4.5	
Terminal Serviceability, P2:	2.5	

PCC Properties

28-day Mean Modulus of Rupture, $(S'_c)'$:	650	psi
Elastic Modulus of Slab, E_c:	3,400,000	psi
Poisson's Ratio for Concrete, m:	0.15	

Base Properties

Elastic Modulus of Base, E_b:	20,000	psi
Design Thickness of Base, H_b:	6.0	in
Slab-Base Friction Factor, f:	1.0	

Reliability and Standard Deviation

Reliability Level (R):	95.0	%
Overall Standard Deviation, S_0:	0.34	

Climatic Properties

Mean Annual Wind Speed, WIND:	8.8	mph
Mean Annual Air Temperature, TEMP:	50.2	^oF
Mean Annual Precipitation, PRECIP:	19.5	in

Subgrade k-Value

71 psi/in

Design ESALs

5.8 million

Pavement Type, Joint Spacing (L)

- (●) JPCP
- ( ) JRCP
- ( ) CRCP

Joint Spacing: 15.0 ft

JPCP

Effective Joint Spacing: 180 in

Edge Support

- ( ) Conventional 12-ft wide traffic lane
- (●) Conventional 12-ft wide traffic lane + tied PCC
- ( ) 2-ft widened slab w/conventional 12-ft traffic lane

Edge Support Factor: 0.94

Sensitivity Analysis

Slab Thickness used for Sensitivity Analysis: 9.18 in

- ( ) Modulus of Rupture
- ( ) Elastic Modulus (Slab)
- ( ) Elastic Modulus (Base)
- ( ) Base Thickness
- (●) k-Value
- ( ) Joint Spacing
- ( ) Reliability
- ( ) Standard Deviation

Calculated Slab Thickness for Above Inputs: 9.18 in

Faulting

DOWELED PAVEMENT

Dowel Diameter:	1.25	in
K_d:	1,500,000	psi/in
E_s:	29,000,000	psi

Base/Slab Frictional Restraint

- ○ Stabilized Base
- ◉ Aggregate Base or LCB w/ bond breaker

ALPHA:	0.000006	/°F
TRANGE:	109.5	°F
e:	0.00015	strain
D:	9.50	in
P:	9,000	lbf
T:	0.45	

Base Type

- ○ Stabilized Base
- ◉ Unstabilized Base

FI:	425	°F-days
CESAL:	5.79	million
Age:	22.0	years
C_d:	1.00	

Faulting (doweled)

0.05 in

Faulting Check - **PASS**

NONDOWELED PAVEMENT

Days90:	30	days
D:	9.18	in

Base Type

- ○ Stabilized Base
- ◉ Unstabilized Base

FI:	600	°F-days
CESAL:	5.79	million
Age:	20.0	years
C_d:	1.00	

Faulting (nondoweled)

in

Faulting Check -

Recommended critical mean joint faulting levels for design (Table 28)

Joint Spacing	Critical Mean Joint Faulting
< 25 ft	0.06 in
> 25 ft	0.13 in

Note: Joint load position stress checks need to be performed only for nondoweled pavements

Only two numbers need to be entered in this sheet:

Temperature gradient

Tensile stress at top of slab

Step 1:

<u>Total Negative Temperature Differential</u>

Slab Thickness: 9.18 in

Total Negative Temperature Differential: -5.4 ^{o}F

<u>Construction Curling and Moisture Gradient Temperature Differential</u>

Enter temperature gradient: 2.0 ^{o}F/in (enter positive value from below)

For temperature gradient use:

Wet Climate:	0 to 2 ^{o}F/in	(Annual Precipitation >= 30 in or Thornthwaite Moisture Index > 0)
Dry Climate:	1 to 3 ^{o}F/in	(Annual Precipitation < 30 in or Thornthwaite Moisture Index < 0)

Total Effective Negative Temp. Differential: -23.8 ^{o}F

Step 2:

Use one or more of the following charts to estimate the tensile stress at top of slab.
Note that the charts show the variation of tensile stress with negative temperature differential for slab thicknesses ranging from 7 to 13 in. These are plotted for a base course thickness of 6 in. The six charts represent three k-values (100, 250 and 500 psi/in) and two values for the elastic modulus of the base (25,000 psi and 1,000,000 psi). Use judgment to extrapolate the value of the tensile stress at the top of the slab from these charts.

Enter Tensile Stress at Top of Slab: 194.37 psi (use charts below)

Step 3:

Compare the above tensile stress with the maximum tensile stress at the bottom of the slab for which the slab is designed. For the given inputs and the above thickness, this value is

239 psi

The slab is designed for a tensile stress of 239 psi.
If the tensile stress at the top of the slab (obtained from the charts below and entered above) is less than the design stress, the design is acceptable. If the check fails, new inputs have to be provided.

Corner Break Check: **PASS**

ESALs and Future Traffic Volumes for Highway 088a

From RefPoint 0 To RefPoint 3

ESAL Calculations are based on the following:
Build Year: 2015
Design Life: 30 years
Number of Lanes: 6

Route	Ref Point	End Ref Point	Length (Miles)	AADT	AADT YR	YR20 Factor	AADT Single Trucks	AADT Comb. Trucks	AADT 2045	AADT Single Trucks 2045	AADT Comb. Trucks 2045	18 KiP ESALs
088A	0.000	0.143	0.161	36,300	2008	1.13	1450	470	45,030	1,799	583	4,924,849
088A	0.143	0.745	0.601	35,200	2008	1.12	1410	490	43,014	1,723	599	4,948,851
088A	0.745	1.090	0.262	37,100	2008	1.14	1370	520	46,709	1,725	655	5,215,961
088A	1.090	1.360	0.362	41,000	2008	1.19	1560	530	55,412	2,108	716	5,790,899
088A	1.360	1.978	0.626	43,500	2008	1.19	1650	570	58,790	2,230	770	6,189,803
088A	1.978	2.961	0.996	37,900	2008	1.17	1400	530	49,820	1,840	697	5,473,323
088A	2.961	3.454	0.501	47,400	2008	1.17	1750	660	62,307	2,300	868	6,825,482
088A	3.454	3.940	0.499	29,300	2008	1.17	1080	410	38,515	1,420	539	4,230,540

If you notice an error, bug or have any questions, Please E-mail us.

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1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Flexible Structural Design Module

PCN 16628
Federal Blvd at 6th Ave

Design for NE Ramp

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,703,966
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	4.94 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	9.18	24	4.04
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	15.18	-	4.94

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Federal Blvd at 6th Ave

Design for NW Ramp

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,858,872
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	5.00 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	9.32	24	4.10
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	15.32	-	5.00

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Federal Blvd at 6th Ave

Design for SW Ramp

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	791,742
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	4.44 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	8.05	24	3.54
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	14.05	-	4.44

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PCN 16628
Federal Blvd at 6th Ave

Design for SE Ramp West of Fork

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,936,325
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	5.03 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	9.39	24	4.13
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	15.39	-	5.03

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PCN 16628
Federal Blvd at 6th Ave

Design for SE Ramp East of Fork

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	1,893,296
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	5.01 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	9.34	24	4.11
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	15.34	-	5.01

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Federal Blvd at 6th Ave

Design for Slip Ramp

Using Valley Highway, Loganto 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	43,029
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	2.85 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	4.43	24	1.95
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	10.43	-	2.85

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PCN 16628
Federal Blvd at 6th Ave

Design for 5th Avenue

Using Valley Highway, Logan to 6th EIS Projections
Adjusted for Design Year, Growth Rate, % DHV to AADT
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	413,083
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	4.04 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	7.14	24	3.14
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	13.14	-	4.04

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Flexible Structural Design Module

PCN 16628
Federal Blvd at 6th Ave

Design for 7th Avenue

Using Traffic Count from City and County of Denver
Westbound 1st Avenue, East of Julian
Assume traffic on side street is 50% of that on 1st

Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/17/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	403,390
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	4.02 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	7.09	24	3.12
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	13.09	-	4.02

Project #	IM 088A-024	
Subaccount	16628	
Description	Federal Blvd at 6th	
Date	2/17/2010	
By	JIC	
WHATS GOING ON???	Determining 18-kip ESALs for side streets	Using Federal Truck %

Given:	Design Hourly Volume from 1/2008

Sea Foam Blue	cells require user input.	What? I didn't know what else to call the color OK???
Green	cells are calculated results of note.	

Traffic Volume

Adjustments[1]	1	(None)

1st Ave	Adjustments None (x 1)	DHV % of AADT	AADT
444	444	9	4,933

Notes:
Source: City and County of Denver, 2008 count, for Project 13810. Federal, Alameda to 5th
[1] Enter 1 if no Adjustments. Update sea foam blue cell in next table as well.

AADT BREAKDOWN

Count Year	2008
Base Year	2015
Last Year of Design	2035

Annual Growth Rate[1]	2 %	
7	-Year Growth Factor	1.15
20	-Year Growth Factor	1.49

Annual Growth Rate Calculator[2]	
Base Year	2015
Projected Year	2035
20-Year Growth Factor	1.19
Growth Rate (%)	0.8736

[1] Manually enter value in % format!!! Based on what you decide to use.
[2] Info from DTD for SH 088A.

Note: Source of Annual Growth Rate = Rate calculated from annual growth rate calculator.

AADT in Count Year	AADT in Base Year	AADT in Last Year	Midpoint AADT
2008	2015	2035	2025
T_0	T_1	T	T_m
4,933	5,667	8,421	7,044

ESAL BREAKDOWN (Yes, it's time for a breakdown!)

Vehicle Breakdown Vehicle Type	%
Cars	94.316
Single Unit Trucks	4.59
Combination Trucks	1.094
Total	100

Equivalency Factors

Vehicle Type	Flexible	Rigid
Cars	0.003	0.003
Single Unit Trucks	0.249	0.285
Combination Trucks	1.087	1.692

Notes: Source is the same source as all the ones above Doofus!

Design Lane Factor	0.6	See 2010 Pavement Design Manual, CDOT Method

Comments:

Used 2 Lane, 1 lane Each Direction Design Lane Factor of 0.6.
Danger! Danger! This can mess you up so chose carefully!

WARNING **20** -YEAR ESALS FOLLOW!!! (And sometimes waaaay too closely!!!) ;o)

Flexible 18-k ESALs

Caution: They can't do full splits!!!

Vehicle Type	# of Vehicles in Design Year	Daily 18-kip ESALs	Design Period 18-kip ESALs	Design Lane 18-kip ESALs
	Midpoint AADT x Vehicle %	A x Equiv. Factor	B x 365 x Design Period	C x Design Lane Factor
	A	B	C	D
Cars	6,643	20	145,490	87,294
Single Unit Trucks	323	81	587,677	352,606
Combination Trucks	77	84	611,467	366,880
Total	7,044	184	1,344,634	806,780

Rigid 18-k ESALs

"Witty" Comment: Hard pavement is good to find.

Vehicle Type	# of Vehicles in Design Year	Daily 18-kip ESALs	Design Period 18-kip ESALs	Design Lane 18-kip ESALs
	Midpoint AADT x %	A x Equiv. Factor	B x 365 x Design Period	C x Design Lane Factor
	A	B	C	D
Cars	6,643	20	145,490	87,294
Single Unit Trucks	323	92	672,642	403,585
Combination Trucks	77	130	951,797	571,078
Total	7,044	242	1,769,929	1,061,957

1993 AASHTO Pavement Design

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Flexible Structural Design Module

PCN 16628
Federal Blvd at 6th Ave

Design for 6th Ave widening

Using DTD Projections
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Date: 2/26/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	7,129,707
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	5.98 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.44	1	11.55	24	5.08
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	17.55	-	5.98

1993 AASHTO Pavement Design

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Flexible Structural Design Module

PCN 16628
Federal Blvd at 6th Ave

Design for 6th Ave shoulder check
(Is shoulder suitable for use as travel lane?)

Using DTD Projections
20 Year Flexible 18-kip ESALs
Base Year = 2015
Midpoint Year = 2025
Last Year of Design = 2035

Assume R=10, 6" ABC CL 6
Used Structural Layer Coefficient of 0.40 to represent old pavement
Date: 2/26/2010
By: JIC

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	7,129,707
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	95 %
Overall Standard Deviation	0.44
Roadbed Soil Resilient Modulus	3,562 psi
Stage Construction	1
Calculated Design Structural Number	5.98 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	New HMA	0.4	1	12.7	24	5.08
2	ABC CL 6	0.15	1	6	24	0.90
Total	-	-	-	18.70	-	5.98

ESALs and Future Traffic Volumes for Highway 006g

From RefPoint 282 To RefPoint 284

ESAL Calculations are based on the following:
Build Year: 2015
Design Life: 20 years
Number of Lanes: 6

Route	Ref Point	End Ref Point	Length (Miles)	AADT	AADT YR	YR20 Factor	AADT Single Trucks	AADT Comb. Trucks	AADT 2035	AADT Single Trucks 2035	AADT Comb. Trucks 2035	18 KiP ESALs
006G	282.333	283.663	1.272	113,000	2008	1.14	3050	1020	134,357	3,626	1,213	5,379,040
006G	283.663	283.863	0.225	124,000	2008	1.14	3220	1610	147,436	3,829	1,914	7,129,707
006G	283.863	284.187	0.344	131,000	2008	1.15	2360	1180	157,528	2,838	1,419	5,562,374
006G	284.187	284.748	0.561	137,000	2008	1.13	2470	1230	161,044	2,903	1,446	5,719,906

If you notice an error, bug or have any questions, Please E-mail us.

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SH088A (Federal Blvd.) over 6th Ave.

Contents

Tenthmile Roadway Inventory

Pavement History

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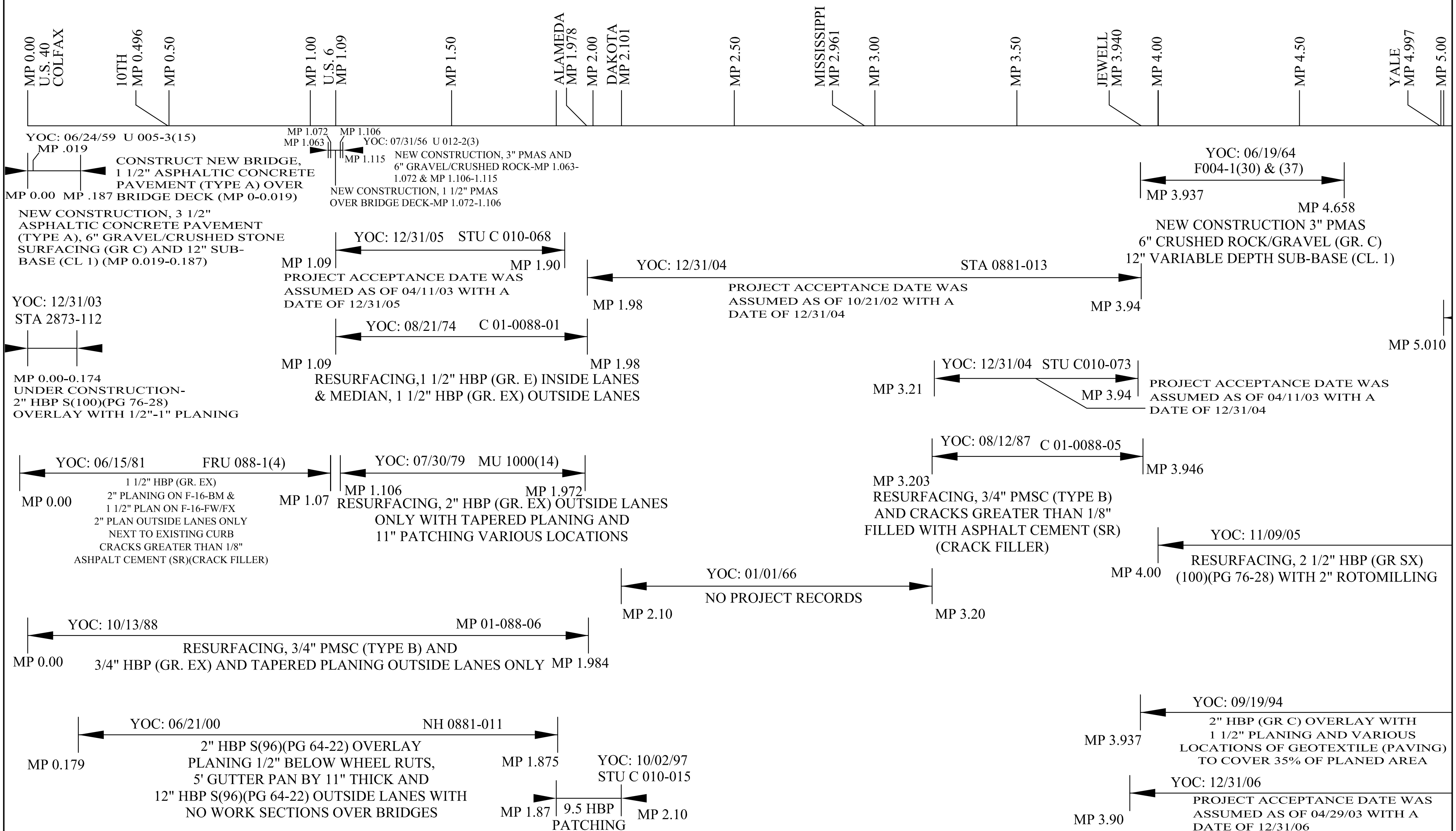
1999 Tenthmile CORIS Database

ROUTE	BEGIN MILEPT	END MILEPT	NHS?	DIVIDED?	NUMBER LANES	LANE WIDTH	DESCRIPTION
088A	0.000	0.040	Yes	Yes	6	12	U.S.40 INTERCHANGE (FEDERAL BLVD) SH 40 E AND W (COLFAX AVE) SH 287 N OVERPASS STR F-16-FW IN DENVER CITY LIMIT POPULATION 467,610 AND URBAN LIMIT BEGIN SH AND FAP ROUTE 88 MILEPOST 0
088A	0.040	0.126	Yes	Yes	6	12	RAMPS ON AND OFF
088A	0.126	0.149	Yes	Yes	6	12	RAMP ON
088A	0.149	0.238	Yes	Yes	6	12	RD E (W 14TH AVE)
088A	0.238	0.309	Yes	Yes	5	11	ASSOCIATED RR SEPARATION 244-708L LAKEWOOD GULCH (BIKEPATH) OVERPASS STR F-16-BM
088A	0.309	0.372	Yes	Yes	5	11	RD E (W HOLDEN PL)
088A	0.372	0.438	Yes	Yes	5	11	RD W (W 12TH AVE)
088A	0.438	0.496	Yes	Yes	5	11	RD E (W 11TH AVE)
088A	0.496	0.623	Yes	Yes	5	11	RD E AND W (W 10TH AVE)
088A	0.623	0.683	Yes	Yes	5	11	RD E AND W (W 9TH AVE)
088A	0.683	0.745	Yes	Yes	5	11	RD E (BARBERRY PL)
088A	0.745	0.812	Yes	Yes	5	11	RD E AND W (W 8TH AVE)
088A	0.812	0.871	Yes	Yes	5	11	RD E (W SEVERN PL)
088A	0.871	0.978	Yes	Yes	5	11	RD E (W 7TH AVE)
088A	0.978	1.000	Yes	Yes	5	11	RAMPS ON AND OFF
088A	1.000	1.054	Yes	Yes	5	11	MILEPOST 1
088A	1.054	1.090	Yes	Yes	5	11	RAMPS ON AND OFF
088A	1.090	1.122	Yes	Yes	5	11	U.S.6 INTERCHANGE (FEDERAL BLVD) SH 6 E AND W (6TH AVE) OVERPASS STR F-16-EK END FAP ROUTE 88 BEGIN FAU ROUTE 88
088A	1.122	1.183	Yes	Yes	5	11	RD E (W 5TH AVE)
088A	1.183	1.186	Yes	Yes	5	11	RD W (W 4TH AVE)
088A	1.186	1.243	Yes	Yes	5	11	RD E (W SHORT PL)
088A	1.243	1.288	Yes	Yes	5	11	RD E (W 4TH AVE)
088A	1.288	1.302	Yes	Yes	5	11	RD W (W 3RD AVE)
088A	1.302	1.360	Yes	Yes	5	11	RD E (W 3RD AVE)
088A	1.360	1.397	Yes	Yes	5	11	RD E (W 2ND AVE)
088A	1.397	1.425	Yes	Yes	5	11	RD W (W 2ND AVE)
088A	1.425	1.488	Yes	Yes	5	11	RD E (W PARK PL)
088A	1.488	1.506	Yes	Yes	5	11	RD E (W 1ST AVE)
088A	1.506	1.547	Yes	Yes	5	11	RD W (W 1ST AVE)
088A	1.547	1.608	Yes	Yes	5	11	RD E (IRVINGTON PL)
088A	1.608	1.612	Yes	Yes	5	11	RD E (ELLSWORTH AVE)
088A	1.612	1.669	Yes	Yes	5	11	RD W (ELLSWORTH AVE)
088A	1.669	1.719	Yes	Yes	5	11	RD E (W ARCHER PL)
088A	1.719	1.728	Yes	Yes	5	11	RD W (W BAYAUD AVE)
088A	1.728	1.826	Yes	Yes	5	11	RD E (W BAYAUD AVE)
088A	1.826	1.853	Yes	Yes	5	11	RD W (W CEDAR AVE)
088A	1.853	1.978	Yes	Yes	5	11	RD E (W CEDAR AVE)
088A	1.978	2.000	Yes	Yes	5	11	JCT SH 26 E AND W (W ALAMEDA AVE)
088A	2.000	2.101	Yes	Yes	5	11	MILEPOST 2

STATE HIGHWAY 088A PAVEMENT HISTORY



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Last Modification Date:	12/28/07	Initials:	TCW
Full Path:	..\		
Drawing File Name:	088A.dwg		
Acad Ver. R2002	Scale: 1"=0.5 MILES	Units: ENGLISH	

Colorado Department of Transportation

DEPARTMENT OF TRANSPORTATION

4670 HOLLY STREET, UNIT C
DENVER, CO 80216
Phone: 303-398-6701 Fax: 303-398-6714

Region 6 Materials

MG

S.H. 088A
PAVEMENT HISTORY

Designer:	BZA	Structure Numbers	
Detailer:	BZA		
Sheet Subset:	XXXXXXX	Subset Sheets:	001 OF 003

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