MINNESOTA DEPARTMENT OF TRANSPORTATION
Engineering Services Division
Technical Memorandum No. 13-19-MAT-01
October 28, 2013

To: Electronic Distribution Recipients

From: Jon M. Chiglo, P.E.
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Subject: Detour Restoration Road Life Analysis using the Equivalent Overlay Method

Expiration
This is a new Technical Memorandum that revises the current procedure contained in the "Detour Management Study Report" dated January 1991. It will remain in effect until October 28, 2018 unless superseded prior to that date.

Implementation
This policy and its instructions are effective immediately.

Introduction
Minnesota Statutes, Section 161.25 provides that the commissioner may designate a street or highway as a temporary trunk highway detour. Section 161.25 also provides that prior to revoking the designation, the commissioner shall restore such streets or highways to as good a condition as they were prior to the designation.

In an effort to provide uniformity and consistency in the method of reimbursing local units of government for use of their roads as detours by MnDOT, a 1991 task force of MnDOT staff and County Engineers recommended a gas tax method formula to compute payments for the use of local government roadways used as trunk highway detours by MnDOT.

The task force also recommended that the local road authority have the option of performing an "equivalent overlay method" analysis at their expense. Testing and analysis to be done by MnDOT approved firm. Any value computed by the analysis in excess of twice the gas tax computation would be included, along with the gas tax formula value, as final payment to the local road authority. The "Detour Management Study Report" is available at http://dotapp7.dot.state.mn.us/edms/download?docId=983637.

The gas tax method formula and equivalent overlay method recommended by the 1991 task force were approved through Technical Memorandum No. 91-20-TS-02 and re-issued as Technical Memorandum No. 92-44-TS-02, and Technical Memorandum No. 96-06-TS-02. The formula used for the gas tax method was revised in Technical memorandum No. 10-09-TS-03.

Purpose
The purpose of this Technical Memorandum is to update the price per inch of an overlay used in calculating the final cost of the Equivalent Overlay Method. This cost has not been updated since the original "Detour Management Study Report" dated January 1991. This document also contains the entirety of instructions for performing the equivalent overlay method analysis so that it may act as the only necessary reference to perform the equivalent overlay method analysis.

Guidelines

Use

The local road authority has the option of performing an "equivalent overlay method" analysis at their expense. A state-approved firm, at no cost or expense to the State, must perform the testing and analysis. Any value computed by the analysis in excess of twice the gas tax computation would be included, along with the gas tax formula value, as final payment to the local road authority.

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This procedure is only applicable to bituminous on aggregate base pavements and full-depth bituminous pavements.

Introduction
The equivalent overlay method analyzes Falling Weight Deflectometer (FWD) data collected on the detour route. Based on the deflections, this method calculates the traffic capacity of the existing pavement structure. If the existing traffic capacity is less than twice the normal traffic plus the detour traffic, then an overlay thickness that will provide the required traffic capacity is calculated. A final cost is calculated from the cost of applying the calculated overlay thickness.

FWD Testing
The equivalent overlay method uses FWD deflection data collected from the detour route. The standard force of the FWD drops is 9,000lbs. The analysis procedure adjusts for typical minor variations in drop force to the standard 9,000lbs. The standard test interval is one tenth of a mile.

Please refer to Attachment A for instructions to calculate the equivalent overlay method analysis.

Questions
Any questions regarding the technical provisions of this Technical Memorandum can be addressed to the following:

- **Tim Andersen, Pavement Design Engineer, at (651) 366-5455**

Any questions regarding publication of this Technical Memorandum should be referred to the Design Standards Unit, DesignStandards.DOT@state.mn.us. A link to all active and historical Technical Memoranda can be found at http://techmemos.dot.state.mn.us/techmemo.aspx.

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Attachments:
A. Equivalent overlay method computations

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Steps to Calculate Equivalent Overlay Income

1. Adjust the center FWD deflection (mils) to the standard drop force of 9000lbs (FWD_{9000}).

$$\frac{9000 \text{ lbs}}{\text{Force of Drop (lbs)}} \times \text{Center Deflection (mils)} = \mathrm{FWD}_{9000}$$

2. Convert the FWD deflection into equivalent Benkelman Beam deflections (BB)

Bituminous on Aggregate - $\mathrm{BB} = 1.05 \times \mathrm{FWD}_{9000} + 5.0$

Full-Depth Bituminous - $\mathrm{BB} = 3.8 \times \mathrm{FWD}_{9000}$

3. Convert the Benkelman Beam deflections (BB) into Benkelman Beam deflections at 80° F using Table 200-1.

Table 200-1

Range of Defl. (Inches)	Temperature in Degrees F to 35	36-45	46-55	56-65	66-75
.000 - .010	.005	.004	.003	.002	.001
.010 - .020	.007	.006	.004	.003	.001
.020 - .030	.010	.008	.006	.004	.002
.030 - .040	.010	.008	.006	.004	.002
.040 - .050	.012	.010	.007	.005	.002
.050 - .060	.015	.012	.009	.006	.003

***All corrections to be added**.

4. Compute the standard deviation of all the BB of the detour segment.

5. Add twice the standard deviation of all BB to each BB_{80}.

$$\mathrm{BB}_{\mathrm{SD}} = \mathrm{BB}_{80} + 2 \times \text{Standard Deviation of all BB}$$

6. Determine the seasonal correction factor from the following tables:

PLASTIC									
Asphalt Surface Thickness	**Date of**								
	5/1	5/16	6/1	6/16	7/1	7/16	8/1	8/16	Sept.
	5/15	5/31	6/15	6/30	7/15	7/31	8/15	8/31	
< 2 in.	**1.12**	**1.29**	**1.44**	**1.53**	**1.60**	**1.65**	**1.69**	**1.73**	**1.79**
> 2 ≤ 3½ in.	**1.17**	**1.34**	**1.50**	**1.59**	**1.63**	**1.67**	**1.71**	**1.73**	**1.75**
> 3½ ≤ 5½ in.	**1.14**	**1.24**	**1.37**	**1.43**	**1.50**	**1.58**	**1.64**	**1.70**	**1.71**
> 5½ < 8 in.	**1.17**	**1.25**	**1.25**	**1.25**	**1.26**	**1.30**	**1.41**	**1.50**	**1.55**
> 8 in. Conventional	**1.13**	**1.18**	**1.16**	**1.13**	**1.15**	**1.18**	**1.29**	**1.37**	**1.45**
> 8 in. Full-Depth Construction	**1.12**	**1.16**	**1.16**	**1.10**	**1.09**	**1.15**	**1.33**	**1.46**	**1.55**

SEMI-PLASTIC EMBANKMENTS									
Asphalt Surface Thickness	**Date of**								
	5/1	5/16	6/1	6/16	7/1	7/16	8/1	8/16	Sept.
	5/15	5/31	6/15	6/30	7/15	7/31	8/15	8/31	
≤ 5 in.	**1.16**	**1.35**	**1.40**	**1.50**	**1.52**	**1.51**	**1.48**	**1.46**	**1.45**
> 5 in.	**1.29**	**1.40**	**1.46**	**1.50**	**1.54**	**1.58**	**1.64**	**1.69**	**1.71**

NON-PLASTIC EMBANKMENTS									
Asphalt Surface Thickness	**Date of**								
	5/1	5/16	6/1	6/16	7/1	7/16	8/1	8/16	Sept.
	5/15	5/31	6/15	6/30	7/15	7/31	8/15	8/31	
≤ 2 in.	**1.30**	**1.41**	**1.72**	**1.79**	**1.83**	**1.83**	**1.88**	**1.88**	**1.88**
> 2 < 5½ in.	**1.21**	**1.36**	**1.47**	**1.53**	**1.58**	**1.56**	**1.52**	**1.49**	**1.44**
> 5½ ≤ 8 in.	**1.00**	**1.02**	**0.98**	**1.00**	**1.05**	**1.05**	**1.07**	**1.11**	**1.11**

7. Multiply each $\mathrm{BB_{SD}}$ by the appropriate seasonal correction factor to convert into BBS.

8. Calculate Daily one-way ESALs for the State and the County roads using Daily ADT and the appropriate conversion factor.

$$\mathrm{ESALs_{County}} = \mathrm{ADT_{County}} \times 0.0214228$$

$$\mathrm{ESALs_{State}} = \mathrm{ADT\ _{State}} \times 0.0529324$$

9. Calculate ESAL capacity from the AASHO equation

$$\mathrm{LOG}\left(\mathrm{ESALs_{capacity}}\right) = 11.06 - 3.25 \times \mathrm{LOG(BBS)}$$

10. Use daily county ESALs to calculate the design ESALs. A growth rate of 3.5% and a 20-year design period is assumed.

$$\mathrm{DesignESALs_{County}} = \mathrm{ESALs_{County}} \times 365 \times 28.28$$

11. Calculate the additional ESALs resulting from the detour

$$\mathrm{ESALs_{Detour}} = \mathrm{ESALs_{State}} \times \mathrm{Days\ of\ Detour}$$

12. Calculate the Excess ESALs.

$$\text{ESALs}_{\text{Excess}} = \text{ESALs}_{\text{capacity}} - 2 \times \text{DesignESALs}_{\text{County}}$$

13. Calculate the overlay ESALs

Case 1 - Excess ESALs < 0

Overlay ESALs = Detour ESALs

Case 2 - Excess ESALs = 0

Overlay ESALs = Detour ESALs

Case 3 - Excess ESALs > 0

a. Excess ESALs < Detour ESALs

Overlay ESALs = Detour ESALs - Excess ESALs

b. Excess ESALs = Detour ESALs

Overlay ESALs = 0
No Payment

c. Excess ESALs > Detour ESALs

Overlay ESALs = 0
No Payment

14. If Overlay ESALs are > 0 then calculate the required BBS with the Detour traffic.

$$\text{LOG}\left(\text{ESALs}_{\text{capacity}} + \text{ESALs}_{\text{overlay}}\right) = 11.06 - 3.25 \times \text{LOG}(\text{BBS}_{\text{Detour}})$$

15. Calculate the overlay thickness based on an 11% reduction per inch of overlay

$$\frac{\left\lfloor \frac{\text{BBS} - \text{BBS}_{\text{Detour}}}{\text{BBS}} \right\rfloor \times 100}{11} = \text{Overlay Thickness (inches)}$$

16. Calculate the cost of the overlay of the segment that the individual FWD test represents (0.1 mile standard).

Overlay Thickness $\times$ \$47,000 (per inch of overlay per mile of 2 lane road)
$\times$ Segment Length (miles)

17. Sum the costs of each segment. This is the final Equivalent Overlay Method cost.