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Pavement Design for Local Roads and Streets

RoadPE: LHI Design Tool Instructions

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Low-Volume Road Thickness Design

RoadPE: LHI Design Tool

The Excel spreadsheet tool, RoadPE:LHI, was developed for low-volume roads under 2,000 vehicles per day. The tool's name LHI, stands for Low-volume Highway Inputs as a reminder that these inputs and design outputs are only valid for low-volume roads and streets.

The concept is to use some very basic inputs which can be determined by a small highway department and use other precalculated inputs and design assumptions to determine the design thickness of a new asphalt layer. Because the tool makes many basic assumptions, it is not applicable for many collector and most arterial highways.

Using the tool is a three-step process.

A. Check the Existing Design
   Input known information about the location, the pavement structure, and the traffic and check the remaining life of the existing pavement structure.
B. Run Design Calculations
   Only four basic choices are available: overlay, mill and fill, rehabilitation, reconstruction. Once the user selects the type of work to be completed, the anticipated design life, and some other basic inputs, the tool will determine the thickness of a new asphalt layer.
C. Tweak the final design (or check existing assumptions)
   Because the tool uses basic assumptions, the user has an opportunity to tweak the final design as needed. This includes checking each step of the initial design.

The details for each step are described below.

A. Check the Existing Design

Since very few new pavements are built, the first step is to determine the remaining life (or percent life used) of the existing pavement). The user needs to input data required in the spreadsheet tool or select from a drop down list. The needed inputs are shown in Figure 1 and shaded blue or green in the spreadsheet. Optional inputs and default values that may be changed by the user are underlined as well. Calculated cells are protected so they cannot be changed.

Items required include those needed for design or proper record keeping. These include:

- Information about the location, route, designer, and date needed for proper recordkeeping.
- **Existing Pavement**. The pavement is only allowed to have 3 total layers: surface, base, and subgrade. While many pavements do have more layers, for low-volume pavement design, the number of layers is limited. Any asphalt layers should be combined into a single layer. User selects the material type from the drop-down list.

RoadPE: LHI - Low-volume Highway Inputs for Pavement Design

Location:	
Route:	
Designer:	
Date:	

Chevlay Location	RoadPE: LHI Version / Date	
C:\RoadPE	Version 1.1	11/21/2019

Input all known data.
Blue cells must be filled out.
Green cells are drop down list to be chosen by the user.
Yellow cells (also underlined) are optional inputs.
Purple cells (also underlined) are defaults that may be changed.
Orange cells are calculated (and protected from changing).
Analysis Steps
A. Check Existing Design
B. Run Design Calculations
C. Override design as needed (or repeat step B)

? Help

Existing Pavement		
Layer	Layer type	Thickness
#		in
1	Cold Mix Asphalt	3.0
2	Uncrushed gravel base (clean)	12
3	Silty soil subgrade	∞
Drainage Quality		Poor
Age of current pavement (last major work)		13 years

Site Inputs					
Seasonal Inputs	Winter	Thaw	Spring	Summer	Depth Frost
Length of Season (days)	23.0	16.0	88.0	238.3	3.2 ft
Avg. Air Temperature (°F)	19.0	33.0	46.0	57.0	

Seasonal Maps

Traffic		
Design Life	25	year
Current vehicles / day	700	vehicles per day
Growth Rate	1.0%	NYSDOT Default = 1%
Traffic Type	Standard LVR	Standard LVR, Agricultural, Commercial, Industrial, Residential

Figure 1. RoadPE:LHI - Existing Pavement Inputs

a. Material Types

A limited catalog of material types are available for design. Details for the expected resilient modulus of the layers is provided on the Materials sheet.

i. Surface Layer

The surface can be hot mix asphalt, cold mix asphalt or gravel. If cold mix is a portion of the full asphalt layer, select cold mix from the drop-down list.

ii. Base Layer

This is the unbound layer over the subgrade and can be one of four material types. More details on which material to select can be found in the full design report manual.

- Crushed gravel/stone base (clean)
- Dirty unbound base (wet)
- Stabilized base (Cement/Asphalt)
- Uncrushed gravel base (clean)

iii. Subgrade Layer

The user should select the dominant material type of the subgrade under the highway. For most of New York State, subgrades are typically silty soil. The order of the list if alphabetical and is NOT indicative of quality. Fill areas thicker than 5 feet should be designed using the material from the fill as the subgrade.

- Clayey soil subgrade
- Gravelly soil subgrade
- Sandy soil subgrade
- Silty soil subgrade

b. Drainage Quality. Drainage quality is good, fair, or poor. Poor drainage is when there is standing water or water is trapped next to the unbound layers of the road. Good drainage includes sites with underdrain, very clean soil, and no evidence of trapped moisture in the spring thaw. If not sure, the user should select fair drainage.

c. Age of the current pavement (years). A critical input, the software uses this number to determine the amount of life that has been used. The last date of major work should be used to calculate the age of pavement, in years. For instance, if the pavement had been paved last in 2003 (current year 2019) with a chip seal in 2012, the age of the current pavement should be 16 years, not 7. This is because the critical failure location is the bottom of the original asphalt layer.

- **Site inputs.** Relevant environmental conditions at the site are seasonal lengths and temperatures and the average depth of frost. There are 4 seasons in the pavement model: winter, thaw, spring, summer. The user needs to input the length of the first three seasons, the average air temperature for all four, and the expected average depth of frost (feet) under the road. Maps produced using data from the Northeast Regional Climate Center at Cornell and the Cornel Pavement Frost Model are provided with the software tool, on the Seasonal Inputs sheet.
- **Traffic Inputs**. The user needs to select a design life desired (from the current year), input the current vehicles per day, and the traffic type. The user may also input a different growth rate from the default of 1 percent recommended.

a. Current vehicles per day. If a traffic count has been done, input this value. The number of vehicles per day can be estimated using a 15-minute count method during the busiest time of day. Typically, this is during the afternoon or morning commute. If there are seasonal differences a more detailed study may be needed. Trucks with trailers should be counted as 2 vehicles. To use this estimation method:

- Take a 15-minute count during the busiest time of day. Convert that value to a daily count using the following formula
- Daily traffic = C*F

C = 15-minute count
F = multiplier based upon type of area:
36 in urban area;
33 in suburban area;
27 in rural area

- As an example, if the count is 106 cars in 15 minutes in a suburban area, the daily count would be 3,500 (106*33=3,498).

This approximation only works if there is free flowing traffic (not a traffic jam).

http://www.clrp.cornell.edu/q-a/212-TrafficCounts.html

b. Traffic Type. There are five traffic spectra available for the user. The calculations and defaults are shown on the traffic page. The calculations include information on the expected number of ESALs (Equivalent Single Axle Loads) to compare the results from RoadPE: LHI against older design tools. The spectra are derived from research and future versions will allow the user to easily put in their own spectra data. Users should contact the Cornell Local Roads Program if they want to use this feature. For each of the traffic types, the percentage of overall trucks is shown below. If not sure, the users should select the Standard LVR traffic type.
    - Standard LVR (12.5% trucks)
    - Agricultural (25% trucks)
    - Commercial (30% trucks)
    - Industrial (50% trucks)
    - Residential (5% trucks and buses)

Once the existing pavement is input, the user can click on the Check Existing button. The calculations will take about 1 minute and will determine the percentage of life used and also alert the user to the anticipated life of the pavement. The percentages are given for both the existing surface and subgrade layer. The life assumes the worst case of the surface or subgrade layer.

B. Run Design Calculations

Design Inputs							
Work Type	User input (thickness - Inches)	Overlay	Overlay, Mill & Fill, Rehab, Reconstruct	1			
Overlay	0.0	Overlay (user may input an override value) [also used with other work types] Use 0 or delete otherwise.					
MillFill	0.0	Mill and fill (user should input what portion of AC remains after milling) - Use 0 if all of the asphalt is removed.					
Rehab	8.0	Rehab (assumes base will be stabilized 8 inches deep and will have stone base quality when done)					
Reconstruct	12.0	Reconstruct (assumes existing road will be removed to the subgrade) – user will be supply base gravel thickness. 12 inches is recommended default.					
Drainage Quality After		Fair					

Figure 2. RoadPE:LHI – Pavement Design Inputs

Once the existing pavement design is complete, the next step is to decide on the work type to be done. For each work type, there are optional inputs to user may select. There are four work types available: Overlay, Mill & Fill, Rehab, Reconstruct.

In each case, the software will determine the thickness of a new asphalt layer. This is done by first calculating the effects of a 2 inch and then 6 inch asphalt layer. The software determines the lifespans of the pavement at these asphalt layer thicknesses and uses this trend to calculate the final thickness (rounded up to the closest ½ inch). The minimum thickness is set to 1.5 inches.

Overlay

Assumes a new asphalt layer over the existing pavement. The existing materials are left in place.

Mill and Fill

Assumes a new asphalt layer replacing a milled section of the asphalt. The user should input what portion of AC remains after milling. Use 0 inches if the entire asphalt layer is to be removed.

Rehab

Rehab assumes the new base will be stabilized 8 inches deep and will have stone base quality when done. User may input a different thickness of the rehabilitated layer. The software assumes the asphalt layer is not reused, but this may be done in the construction phase.

Reconstruct

Reconstruct assumes existing road will be removed to the subgrade. The user needs to supply gravel thickness. 12 inches is recommended default. The new gravel is assumed to be clean gravel.

- Drainage
  The final input is the drainage after the work is done. Unless the agency is spending a large amount on drainage, the drainage quality after the work should be no more than one grade better than before (poor → fair, fair → good).

Once the inputs are complete, the user can click the Run Design button. The calculations will take about 3 minutes and will determine the new asphalt layer thickness (cell H41) and also alert the user to the anticipated life of the new pavement. The life calculations check the existing surface and subgrade layers as well as the new asphalt layer.

C. Tweak the final design

Because *RoadPE: LHI* make a large number of assumptions, there are times when a design may not be as precise as possible. The results of all the calculations are available for the user to examine, should the output seem inappropriate. This information can be found in the Output and Summary sheets. Finally, the user can override the amounts of asphalt and see the effect of the new thicknesses.

Life already consumed from any existing pavement will affect the lifespan of the of any recommended repair. For instance, overlays on pavements that have lost a large percentage of their service life will have lower projected lifespans or require extra thickness because the existing surface layer will not have the capacity to handle the expected fatigue damage even after an overlay is applied. The tool will model 2” and 6” overlays and use that information to extrapolate an overlay thickness that will provide a design with the service life called for in cell E25.

In order to check a single step or check a new layer thickness, the user sets the step to be used in the trial number cell (cell J39) and uses the Tweak or One Step button to calculate the single step or new design values.

Design Trials									
Program will supply design thickness of the new asphalt concrete layer.									
	Trial	1	2	3	4		Current Trial		
		Existing	2"	6"	**Calculated**		Thickness	Type	
Layer	Layer type	Thickness	Thickness	Thickness	Thickness	Trial	**4**		
#		in	in	in	in	layer 1	3.5	Cold Mix Asphalt	
	New Asphalt Layer		2.0	6.0	**3.5**	layer 2	3.0	Cold Mix Asphalt	
1	Cold Mix Asphalt	3.0	3.0	3.0	3.0	layer 3	12.0	Uncrushed gravel base (clean)	
2	Uncrushed gravel base (clean)	12.0	12.0	12.0	12.0	layer 4	23.4	Silty soil subgrade	
3	Silty soil subgrade	23.4	23.4	23.4	23.4	layer 5	0.0	Silty soil subgrade	
	Life (years)	13	25	25	25	life	25		
	Drainage	Poor	Fair	Fair	Fair	Drainage	Fair		
		3	2	2	2				
Lifespan consumed	AC Overlay		0%	1%	0%				
	AC Existing	78%	31%	2%	11%				
	Subgrade	43%	5%	0%	2%				
	Life Used (percentage) (Existing + Future)		109%	80%	89%				
	Life (Calculated in years)	4			28				

Figure 3. RoadPE:LHI –Design Trial Results