Spring 4-13-2020

Early Warning Model of Dangerous Road Pavement Condition Using UAV

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Elite Engineering Group (EEG)

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Flexible Pavement

Montana predominantly utilizes flexible pavements. MDT refers to this as plant mix surfacing (PMS). In rare instances, MDT uses rigid pavement commonly referred to as Portland cement concrete pavement (PCCP). Currently, flexible pavements make up about 97% of MDT's road system (excluding gravel roads).

A flexible pavement can consist of up to four layers -- subgrade, subbase (often omitted), base, and surfacing. These pavement layers are described as follows:

- Surfacing usually consists of PMS, but may consist of a double shot (double chip seal) on very low-volume roads. PMS typically is chip sealed, except when specifically designed to be less permeable such as 3/8" Grade S PMS.
- The base course usually consists of an untreated gravel base or cement-treated base.
- Subbase can consist of a sand surfacing, special borrow, or uncrushed gravel placed on the subgrade.
- Subgrade is the native material beneath the surfacing section.

The recommended PMS, base, subbase, and special borrow thicknesses are shown in Exhibit 5-4. Plant mix thickness is based on daily ESALs during a 20-year pavement design life.

Exhibit 5-4
Pavement Layer Thickness

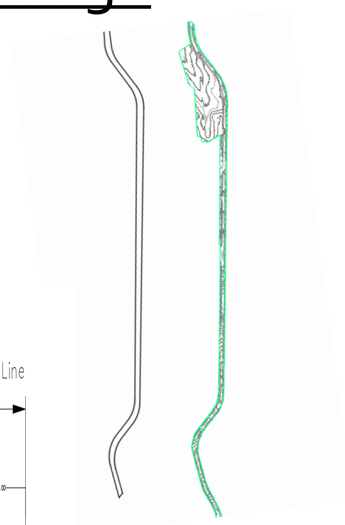
(ESAL value of 41)

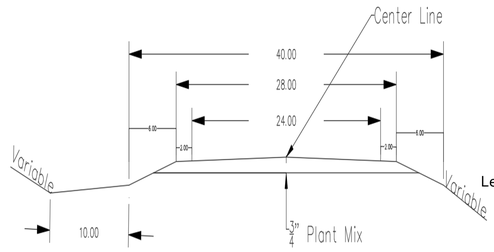
PMS		Base Course / Subbase / Special Borrow	
ESALs (Daily)	PMS Thickness[1]	Material	Thickness
>2000	0.70'	Crushed Aggregate Course (CAC)	0.65' min.
1000 – 2000	0.60' – 0.70'	Cement Treated Base (CTB)	0.65' min.
501 - 1000	0.50 – 0.60'	CAC/CTB pulverized in place	0.50' min.
201 - 500	0.40 - 0.50'	Subbase Course	0.65' min
101 – 200	0.30 – 0.40'	Special Borrow	2.0'
0 - 100	0.30'[1]		

[1]In certain cases 0.25' of PMS can be used for ½" or 3/8" mix, when budgets are constrained.

Geometric Design

- Designed using:
  - MDT Geometric Design Standards
  - MDT Road Design Manual
- Calculated:
  - Alignment R Min: 590 ft
  - Superelevation Runoff Length: 272 ft
  - Tangent Runout: 68
  - Lane Width: 12 ft
  - Shoulder Width: 2ft





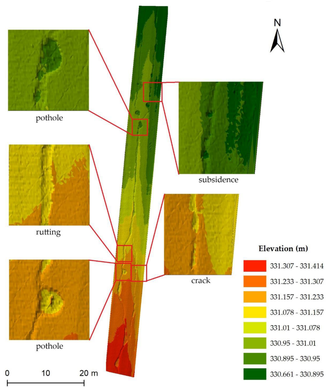
Left: Redesigned Road Right: Current Road

Identify Using UAV

The purpose of the early warning model is to monitor roadway conditions and imperfections before it becomes a larger issue. It is helpful in making the roads safer and more efficient. Once data is collected, distresses found in the road are categorized and put into inventory. We found UAV Lidar to be the most useful form of collecting data. The state of Montana has a Lidar inventory which could be used as a platform for lidar data to be exchanged throughout the state.

UAV Lidar

- Unmanned aerial vehicle with an airborne laser scanner
- Near-Infared laser beam
- Accuracy within 15 mm
- The sensor enables high-speed data collection
- Useful in determining road conditions in the most efficient manner



UAV Lidar Example

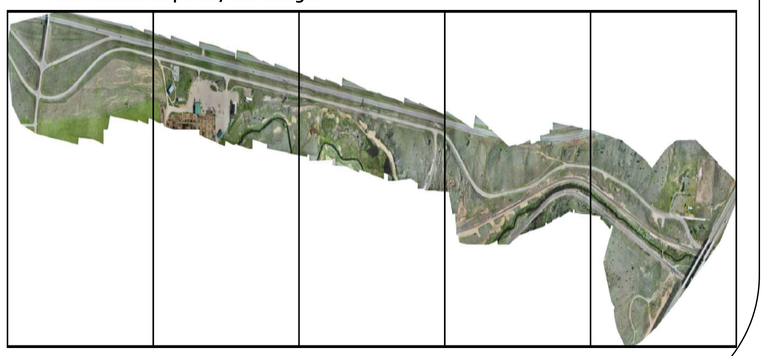
Distress Classification Table

Type of Distress	Length/Width/Depth	Grade	Thumbnail Photo
Multiple Longitudinal & Transverse Cracks	10~12m/1~2cm/--	Length>8m; Severe	
Multiple Longitudinal & Transverse Cracks	5~7m/1~2cm/--	Width<5cm; Multiple Cracks; Severe	
Transverse Crack	~7m/5~7cm/4~6cm	Width and Depth>5cm; Severe	

Background

The inspection process of road pavement safety varies in size in length, and many local and federal authorities are responsible for such work. Using unmanned aerial vehicle (UAV) technology has proven to be cost effective in road construction, maintenance and inspection work. Rapid deployment in response to user satisfaction and concerns is also a viable prospect for the use of UAVs. MDT has identified a portion of Nissler Road between Ramsay, Montana and the I-15/I-90 interchange west of Rocker as a candidate for enhanced roadway safety inspection using UAVs.

Stephen Frazee of WET in Butte kindly provided our team with an UAV image they took of the road. With this image and some site visits, the goal of our senior design project will be to complete a geometric and pavement redesign of the given road and also develop an early warning process with UAV that includes; Inspect, Call for Immediate Response, and Design.



Recommendations

- The given road needs to be fully reconstructed, not just patch repair
- Flexible pavement should be used over rigid pavement
- An early warning system using UAV technology should be used to identify roads that need service
- Once identified, an inventory of the distresses should be created
- From this inventory, decisions can be made whether or not to act on the road
- Using Montana's Lidar inventory would be a revolutionary way for many different parties involved to access useful data that could be used to improve roadways