

Executive Summary and Implementation

Nebraska Specific Slope Design Manual

Research Objectives

- Classification of typical failure pattern for slope failure.
- Documentation of soil properties at failure by back-calculation.
- Documentation of soil properties at weathered (final) condition and unweathered (initial) condition by experiment.
- Documentation of graphics showing the failure development in the critical layer with time dependent strength loss (for technology transfer).
- Analysis of the factor of safety based on the reduced soil strength.
- Analysis and test for maintenance and retrofitting techniques (chemical techniques and physical techniques).
- Final documentation of the new Nebraska-specific slope design, maintenance and retrofitting manual for typical failure pattern and typical geological patterns.

Research Benefits

- Safer but more economic slope design.
- Retrofitting existing slopes with more resilient but economic techniques.
- Enhancing the safety and drivability of highways in Nebraska.
- Prolong the life of roadway system.
- Reducing the disturbance to traffic.

Principal Investigators

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Lead TAC Member

Mark Lindemann,

Background

The proposed research will develop a Nebraska specific slope design, maintenance, retrofitting standard/manual. To that end, literature review on the geological and geotechnical conditions and associated slope failures will be investigated. Based on this literature review, visiting to several (five sites are proposed at the time of proposal preparation) failure sites in Nebraska will be made. For the selected sites, field geotechnical tests (e.g. vane shear tests) and surveying will be conducted. Soil samples will be taken and laboratory tests (strength tests and permeability tests) will be conducted in the lab. Based on these field and lab data, a Nebraska specific slope design, maintenance, retrofitting standard/manual will be developed. In the process, the following detailed documentations will be developed as dedicated chapters.

Proposed Implementation by the Principal Investigator

This research is intended to provide a detailed design/retrofitting standard/manual which is primarily aimed to be easily implemented by design and field engineers. Seven detailed documentations listed in "Objective" are also expected to be implemented by NDOR engineers.

The majority of information used in this proposal is from Mr. Mark Lindemann, NDOR's geotechnical engineer. The research team will work closely with Mr. Mark Lindemann's team so that engineers in NDOR will naturally become familiarized to this work. In addition PI and Co-PI of this research also provide technology transfer sessions.

Conclusion

This study recommends that the consolidated drained strength be used for the design of new slopes and retrofitting techniques. Among several retrofitting techniques, earth anchor and biopolymer based reinforcement are recommended. Earth anchors are recommended because the resisting force is provided by deep soil layers which are free from weathering and associated strength reduction. Biopolymer based soil treatment is recommended because the technique showed promising weathering resistance in this research. However, biopolymer based soil treatment technique is not thoroughly verified, further verification research may be needed.

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Interested in finding out more?

Final report is available at:
[NDOT Research Website](#)

Recommendations for Implementation

Certain locations within Nebraska are prone to slope failures that affect our roadways, specifically eastern Nebraska with a high concentration of failures occurring in District 3 where shale or high plastic clays are present. This research looks at the traditional methods of analysis and design of both existing failed slopes and new embankment construction where failure is likely and provides some new innovative ideas on how to repair or construct these embankments safely and economically. The information gathered through this research will be used to perform a more comprehensive analysis and design of embankments and repaired slopes, specifically by using the reduced long-term strengths (residual shear strengths) of shales and high plastic clays that has been observed in the research testing to better estimate the long-term stability of slopes. In addition, we plan to use the new technology available to monitor slope movement with drone and fiber-optic based survey methods to get a bigger picture of the entire slope geometry and movement. We anticipate using the design information that is provided in this research to incorporate the use of helical anchors to mitigate slope movement as this construction method has become more popular in Nebraska in recent years. Finally, additional research will be performed using biopolymer additives to stabilize soils.

**This brief summarizes Project SPR-P1 (17) M061
“Nebraska Specific Slope Design Manual”
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