

Executive Summary and Research Readiness Level Assessment

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 showed 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.

Background

The proposed research developed 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 were conducted. Soil samples were taken and laboratory tests (strength tests and permeability tests) conducted in the lab. Based on these field and lab data, a Nebraska specific slope design, maintenance, retrofitting standard/manual was developed. In the process, the following detailed documentations was developed as dedicated chapters.

Conclusion

This study recommended 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 was 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.

Principal Investigators

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

NDOT Recommendations Based of completed Research Project I 2018 - Level 4

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 looked 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.

- As provided by Mark Lindemann, Lead TAC Member

NDOT Recommendations Based of Completed Research Project - 2022

Upon completion of this research project, the information provided by this research has been implemented into NDOT's slope repair and design projects. By using the manual provided, NDOT is able to accurately predict long term strength values (residual shear strengths) of shales and high plastic clays using traditional borings with lab testing and CPT testing.

By using the residual shear strength values repaired slopes are less likely to have reoccurring issues saving NDOT long term maintenance and repair costs. Using new technologies such as drone surveys, NDOT is able to monitor the slope to ensure no movement is occurring. If any issues arise, they can be taken care of immediately without have to fully reconstruct the embankment. In addition, NDOT is currently actively monitoring slope repairs where the manual design values were used and have seen good results.

- As provided by Nikolas Glennie, Lead TAC Member

Research Readiness Level (RRL) Assessment Level 5: Standard Practice

-Research/Technology fully Implemented and understood. No follow up is necessary

RRL 5

**This brief summarizes Project SPR-P1 (17) M061
"Nebraska Specific Slope Design Manual"
Nebraska Department of Transportation Research Program**