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**Sponsor**

Michigan Department of  
Transportation (MDOT)

**Project Title**

Resilient Modulus at the  
Limits of Gradation and  
Varying Degrees of Satur-  
ation

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# Project Summary

Technology Transfer Outreach Publication

## An Analysis of Michigan Roadway Aggregate Materials by the Resilient Modulus Method

Soil and aggregate specifications typically specify gradation by a percentage range at the various sieve sizes. There may be pressure to broaden the acceptable limits for materials to qualify within a particular specification, and if this is done, there is a question as to whether the characteristics intended by the specification have been compromised.

### Research Objectives

The objective was to determine whether the compacted stiffness of the aggregate material varied as a function of gradation *WITHIN* the specification at various moisture conditions.

### Methodology

Four aggregate materials were evaluated. They were quarried dolomite, crushed natural gravel, crushed slag, and recycled portland cement concrete. The environmental conditions modeled were the saturated condition, the as-compacted condition, and two intermediate moisture contents intended to simulate drainage due to infiltration through cracks in the pavement and capillary saturation. All test specimens were compacted to the same percentage of maximum compacted unit weight and tested similarly.

The stiffness was measured as the resilient modulus and the conventional AASHTO protocol was used for determination of the resilient modulus.

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## University Facts

Total Enrollment	6,550
Graduate Enrollment	916
Number of Faculty	417
Placement Rate	95%

*Michigan Tech is located in Houghton, MI on the south shore of Lake Superior. This rural area is known for natural beauty, pleasant summers, abundant snowfall, and numerous all-season outdoor activities. In addition, the University maintains its own downhill and cross-country ski facilities and golf course. There are numerous cultural activities and opportunities on campus and in the community. Michigan Tech has also been rated as one of the safest college campuses in the United States, and the local community provides excellent resources conducive to an outstanding quality of life.*

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## Research Findings

The results showed, for all materials tested, that the resilient modulus was influenced by the material's moisture content, and that the critical condition was complete saturation. Further, it showed that drainage (this material specification is usually regarded as yielding a free draining material) was quite variable within the specification and that this influenced the stiffness.

An alternative method of analyzing the results of the resilient modulus determination was developed. This development allowed material performance differences to be easily determined at the 95% confidence level. The analysis method also demonstrated that the stiffness is, in part, a function of the specimen conditioning which occurs as part of the testing protocol.

## Benefits

- This project showed the behavior variability within a common aggregate specification. Changing the specification will make the behavior more predictable.
- It demonstrated the importance of water drainage from the material in the service environment. Changing the specification will increase the longevity of the pavement system.
- It developed an analysis method which allows the engineer to defend the decision for using one material rather than another when both meet a simple gradation specification.

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