Compressibility Assessment of Roadway Embankments Using Tire Derived Aggregates (TDA)

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Research Background

- In North America, more than 280 million scrap tires are generated each year, with 30 million in Canada and 250 million in the United States
- These waste tires either go to landfill or stockpile
- Scraped tires disposed of in landfills can lead to a public health hazard and affect the surrounding natural environment
- Researchers across the world are trying alternative uses of scrap tires
- Roadway embankment construction using tire-derived aggregates (TDA) is the most popular and ecologically viable method due to large amount of consumption of material in the embankment

Problem Statement

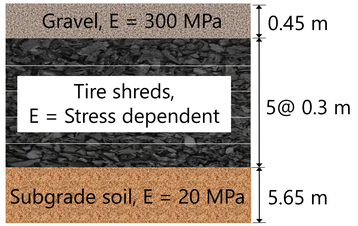
- TDA's deformability/ compressibility under applied load is an important consideration for the design of tire shred embankment
- There is a lack of quantitative information on the compressibility characteristics of tire shred embankments

Research Outline

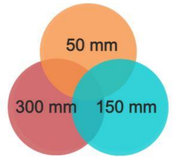
- Finite element (FE) method is applied to assess the compressibility of the tire shred embankment
- Linear and nonlinear compressibility analysis of tire shred embankment is performed, assuming a multilayer elastic-isotropic system
- Two-D axisymmetric and 3D finite element (FE) analysis is employed with a linear and nonlinear elastic material model for the TDA
- The results from the FE analysis and the deflections calculated by a multilayer computer software, KENLAYER, are then compared to examine the effectiveness of the models in calculating the TDA deformation

Modelling Approach

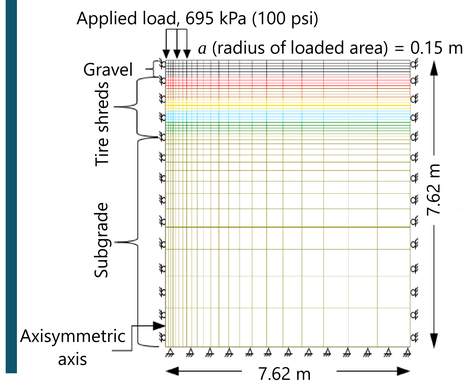
Cross-section of TDA embankment



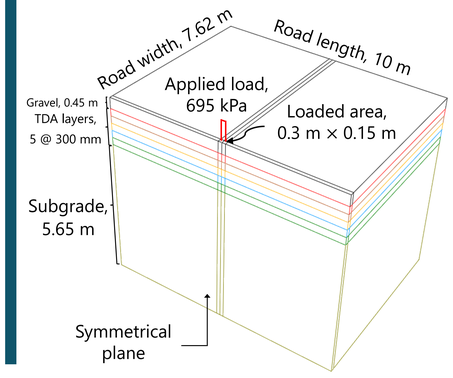
Tire shred size



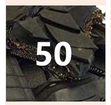
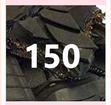
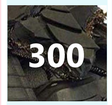
FE Model (2D Axisymmetric)



FE Model (Symmetrical 3D)

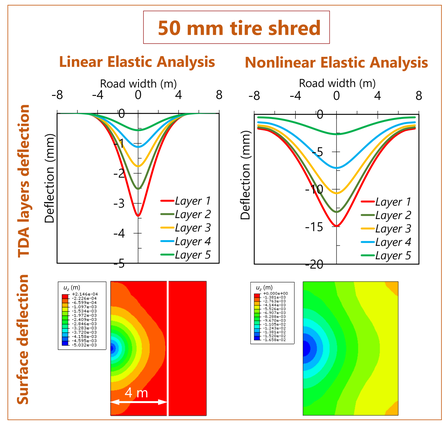


Material Model

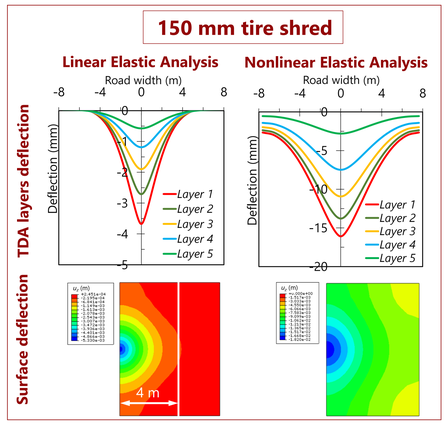
TDA size (mm)	Depth (mm)	Vertical stress (kPa)	Stiffness Modulus (kPa)	TDA size (mm)	Depth (mm)	Vertical stress (kPa)	Stiffness Modulus (kPa)	TDA size (mm)	Depth (mm)	Vertical stress (kPa)	Stiffness Modulus (kPa)
	600	69.50	175		600	69.24	125		600	69.22	122
50	900	37.84	110	150	900	37.31	75	300	900	37.27	71
	1200	27.39	75		1200	26.33	65		1200	26.25	62
	1500	23.26	50		1500	21.67	45		1500	21.55	42
	1800	21.72	35		1800	19.60	30		1800	19.44	21

Results (Axisymmetric 2D Analysis)

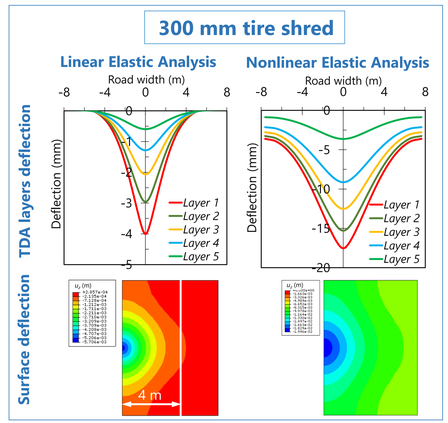
50 mm tire shred



150 mm tire shred

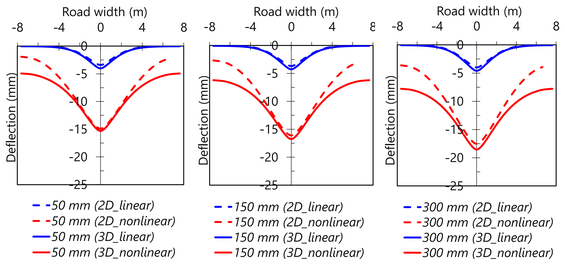


300 mm tire shred

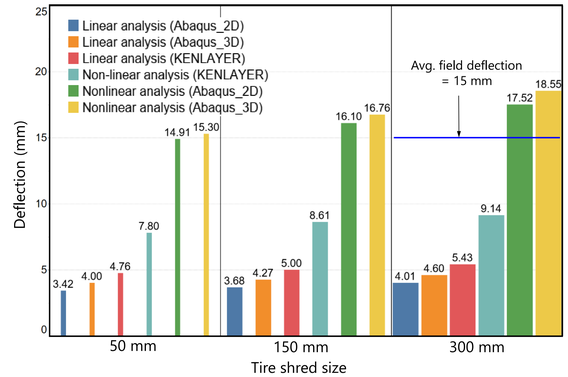


Results

Surface Deflection of Linear and Nonlinear Compressibility Analysis



Comparison of Predicted Deflections



Conclusions

- Deflections of the tire shred embankment based on nonlinear elastic analysis are significantly higher (as much as 300%) than the deflections calculated using linear elastic model
- Deflection values for 300 mm tire shreds are approximately 10% and 20% higher than the values for 150 mm and 50 mm tire shreds, respectively
- Calculated deflections are higher (3-6%) from 3D FE analysis than from 2D axisymmetric FE analysis
- Settlements calculated using nonlinear FE analysis are significantly higher (as much as 100%) than the settlements calculated using the pavement design/ analysis software 'KENLAYER'