Master’s Thesis Engineering Technology

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Effects of decelerated moving load of automated vehicles on the pavement stress-strain responses using 3-D finite element modelling

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Problem Definition

Automated (driverless) vehicles, or AVs, will become more prevalent in the future.

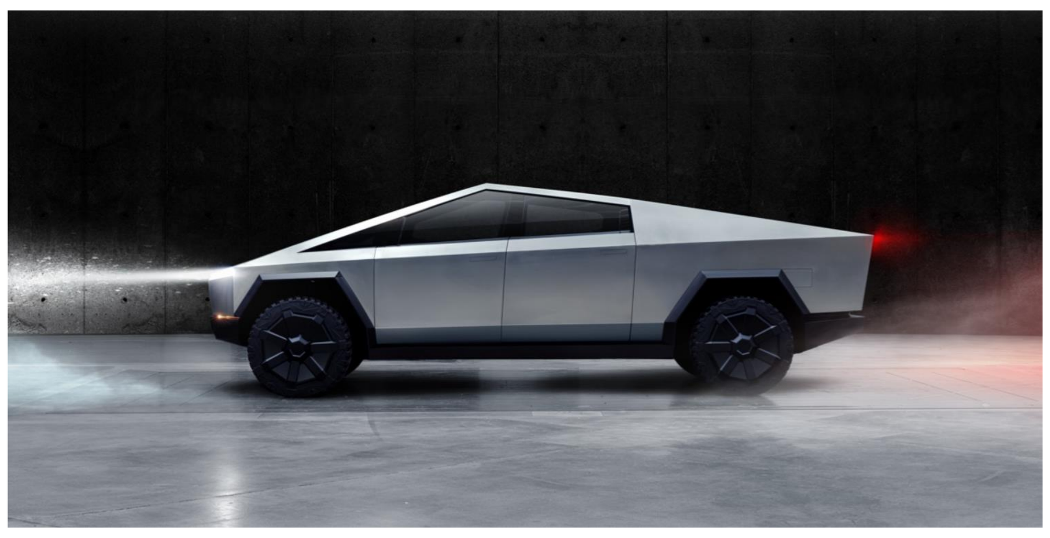

Figure 1: Tesla Cyber Truck

How will these new types of vehicles affect the road pavements ?

Main research question:

What are the potential impacts of the deceleration behaviour of AVs on stress-strain response of HMA pavements?

sub research questions:

- Difference in deceleration behaviour between AVs and non-AVs?
- What stress-strain forces do the different deceleration models produce?
- What are the characteristics of an HMA-pavement?
- How does an HMA-pavement react to the stress-strain produced by decelerating moving loads?
- How should the information acquired be put into an ABAQUS-model?

Method and Material

Specification of the setting of the study

HMA (hot mix asphalt) was characterized as a viscoelastic material.

The pavement examined is part of the Virginia Smart road – section B [1].

Deceleration behaviour

Determination of the difference between the deceleration behaviour of AVs and Non-AVs.

Proposed behaviour based on assumptions and hypothesis that AVs are more efficient and eliminate driver error.

Non-AV (human) deceleration behaviour can be characterized as parabolic deceleration [2].

Linear deceleration model proposed for AVs.

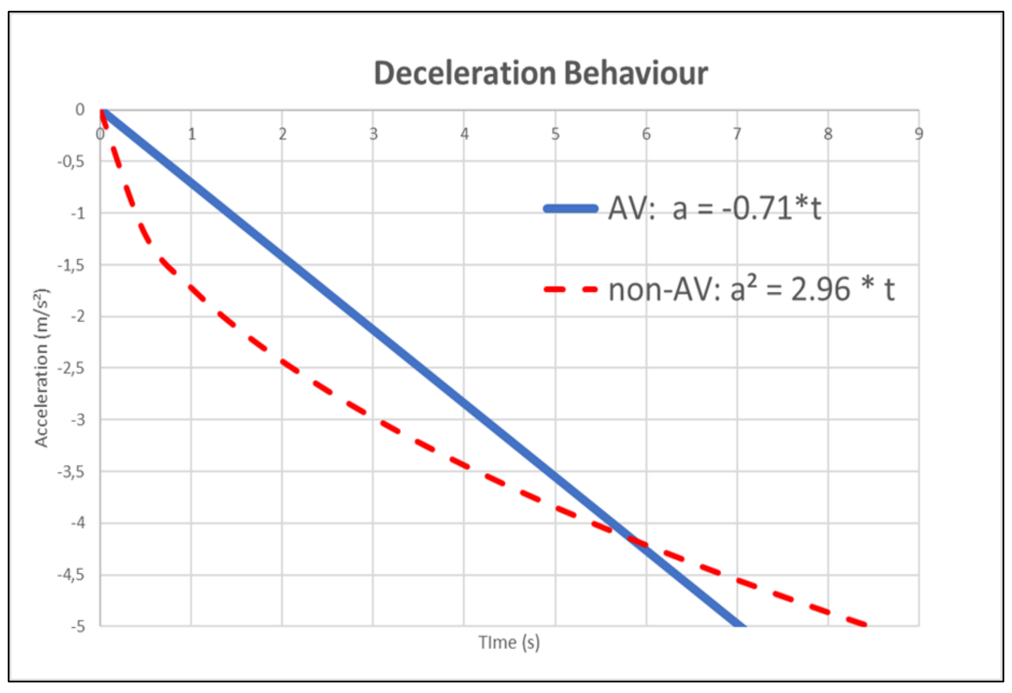

Figure 2: Deceleration behaviour for AVs and non-AVs

Hypothesis

Harsher deceleration will result in more damage to the pavement.

Harsher Deceleration => Higher peak stress/strain.

AV causes less damage to HMA-pavement.

ABAQUS Modelling

Model based on previously designed models. Studies by Al-Qadi et al. [3].

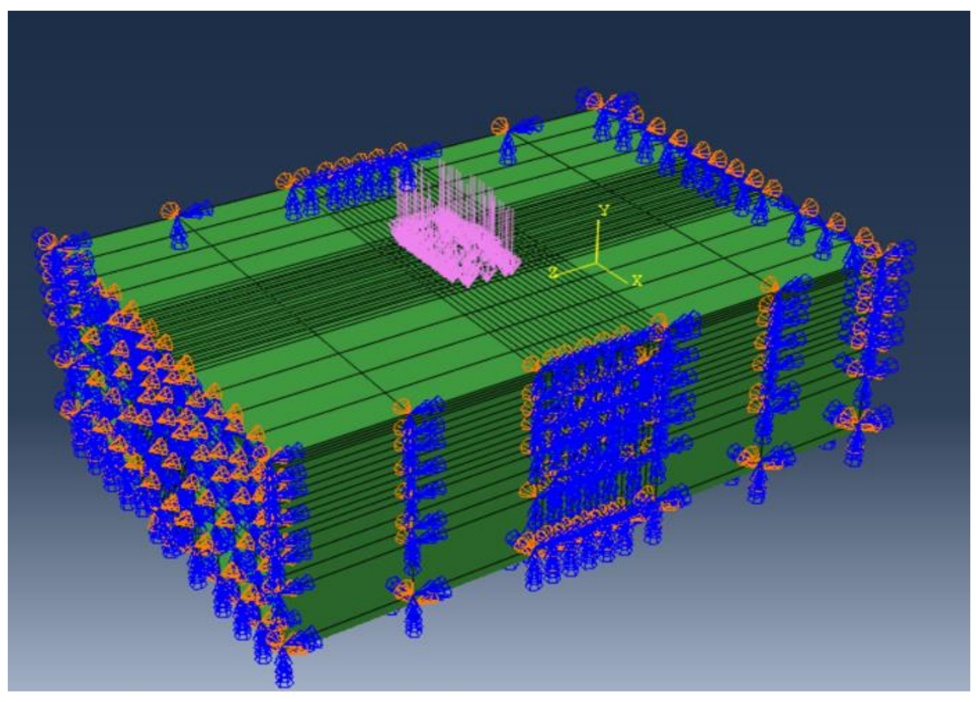

Figure 3: ABAQUS Pavement Model

Validation

Validation was done by mimicking a model from a study by Yoo and Al-Qadi [3].

Remaining Inaccuracies

Several inaccuracies remain in the model:

- No transversal loading.
- Loading area length.
- Fully bonded layers.

Bibliography:

[1] O. E. Gungor, I. L. Al-qadi, and A. Gamez, “In-Situ Validation of Three-Dimensional Pavement Finite Element Models In-Situ Validation of Three-Dimensional Pavement Finite Element Models,” no. September, 2016, doi: 10.1007/978-3-319-42797-3.

[2] S. P. Deligianni, M. Quddus, A. Morris, A. Anvuur, and S. Reed, “Analyzing and Modeling Drivers ’ Deceleration Behavior from Normal Driving,” doi: 10.3141/2663-17..

[3] P. J. Yoo, I. L. Al-Qadi, M. A. Elseifi, and I. Janajreh, “Flexible pavement responses to different loading amplitudes considering layer interface condition and lateral shear forces,” *Int. J. Pavement Eng.*, vol. 7, no. 1, pp. 73–86, 2006, doi: 10.1080/10298430500516074.

Results and Conclusions

longitudinal strain		Max Value (µm/m)	Mean Value (µm/m)	Diff Max Value (%)
Non-AV	Outer rib	-28,7574	-21,30083758	0,007302468
AV		-28,7595	-21,30107091	
Non-AV	Centre rib	-36,754	-24,62845333	0,02475921
AV		-36,7631	-24,62442848	

Figure 4: Longitudinal strain results for the different tyre ribs

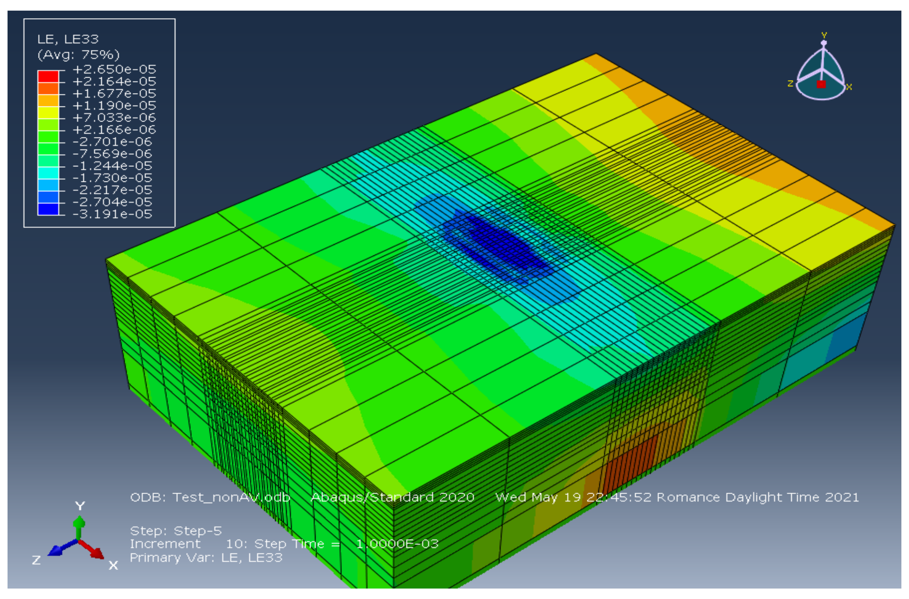

Figure 5: Longitudinal strain for outer tyre rib

Results:

No difference in peak stress/strain.

Possible Explanations:

- Lack of difference in speed and loading time.
- Only one vehicle pass simulated.
- Limited method of simulating braking.

Conclusion:

No difference in effects on pavement between AV and non-AV deceleration. More research required.

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