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AN IMPROVED TOOL FOR M-E EVALUATION OF PAVEMENT PERFORMANCE

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Outline of the Presentation

Improving the numerical modelling for pavement analysis

1. Pavement (structural) performance
2. M-E evaluation of pavement performance
3. Loading cases
4. Materials models
5. Numerical integration and its challenges
6. Efforts to improve accuracy and speed
7. Some examples
8. Concluding Remarks

1. Pavement (structural) performance

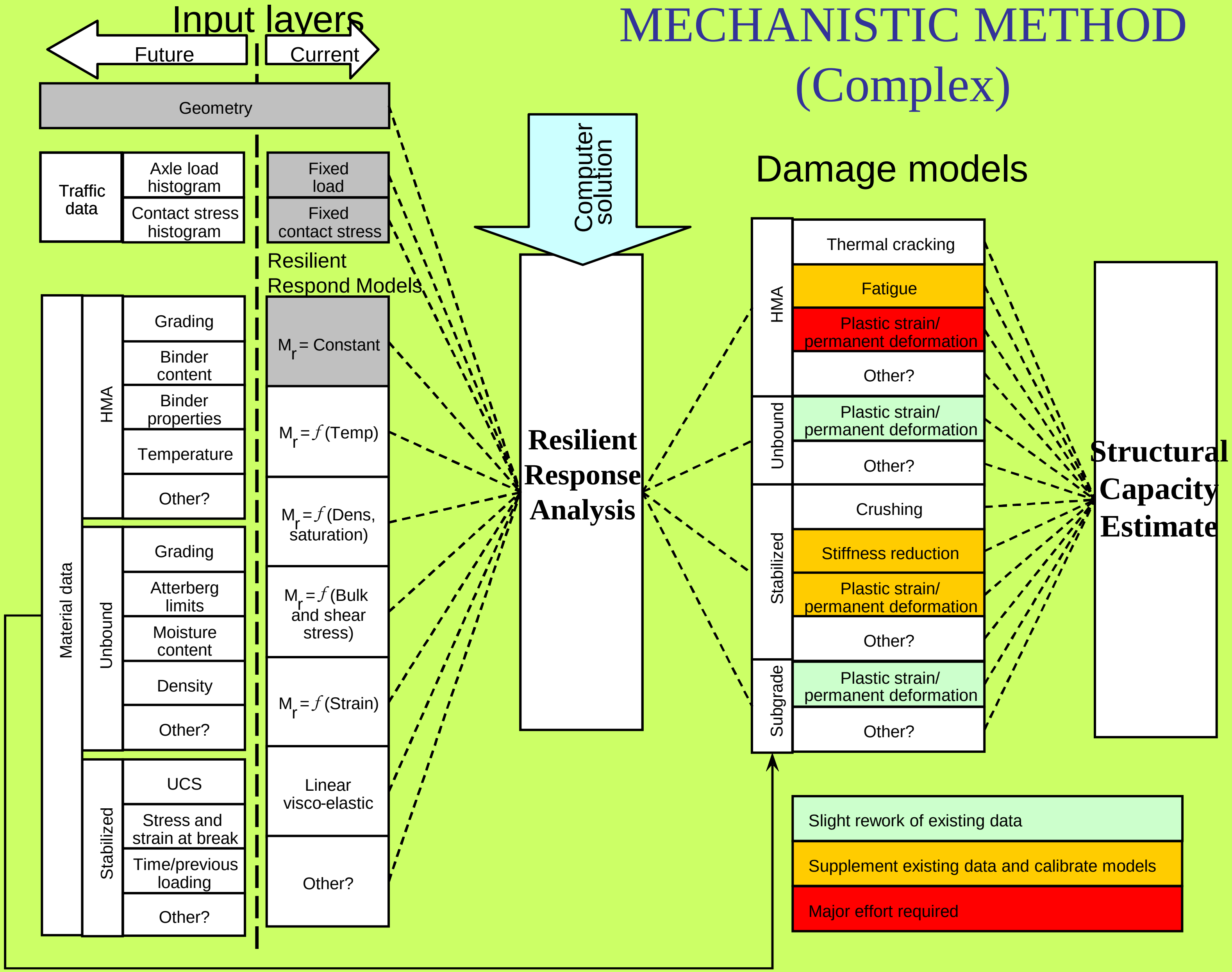
Fatigue cracking and ageing

rutting – plastic deformation

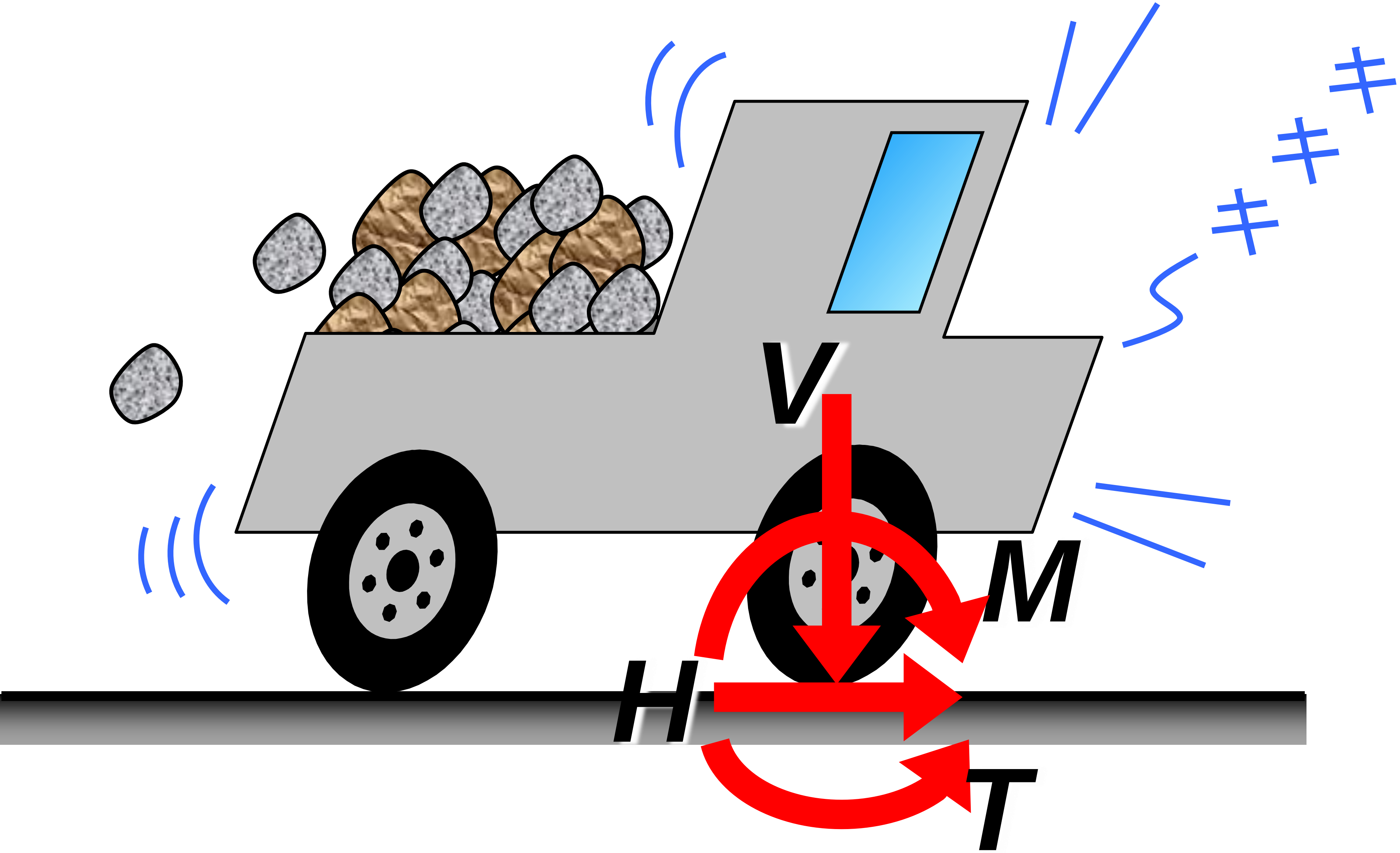
shoving – start and stop

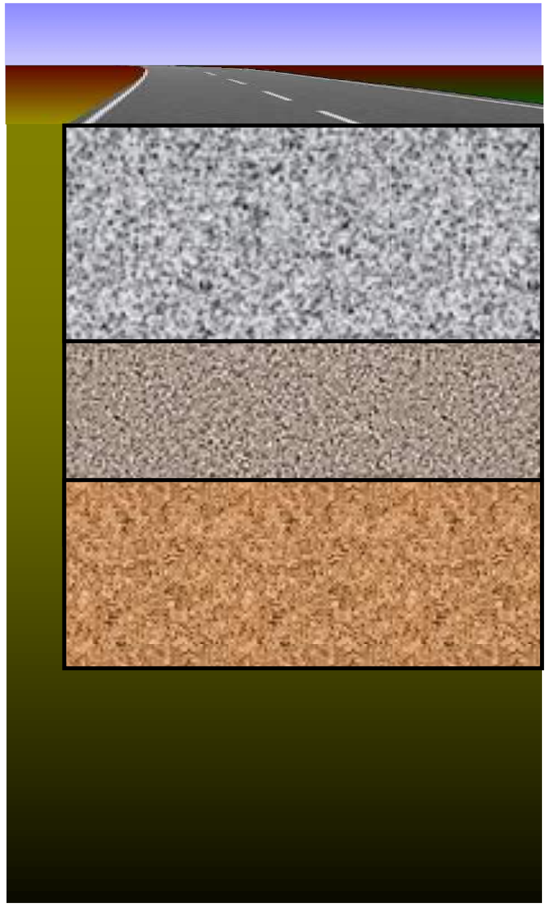
2. M-E Evaluation of Pavement Performance

MECHANISTIC METHOD
(Complex)



3. Loading Cases





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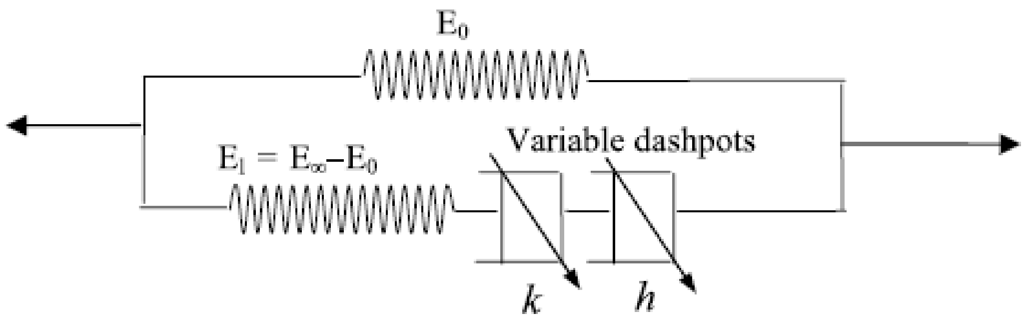
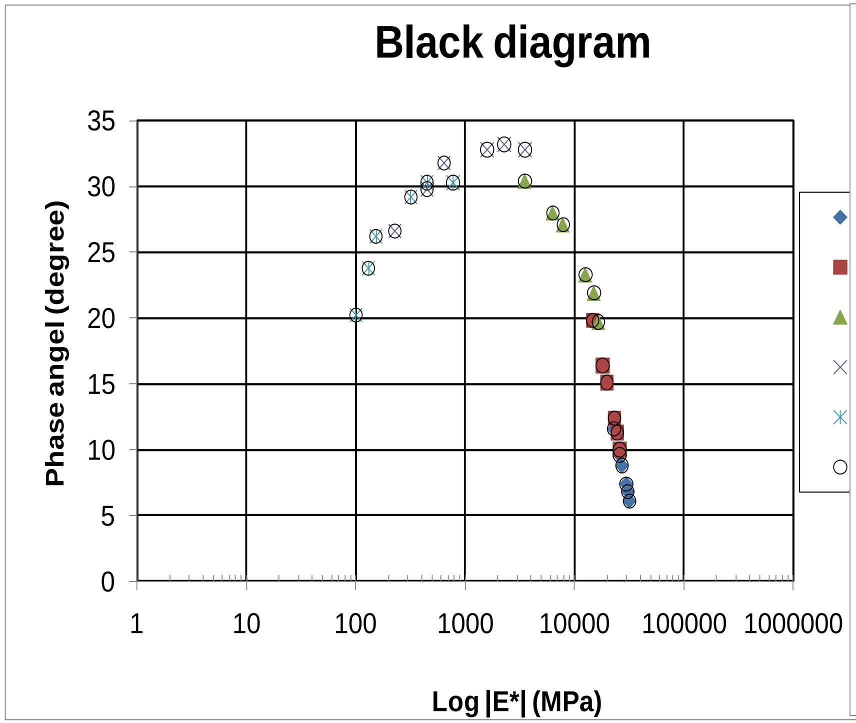
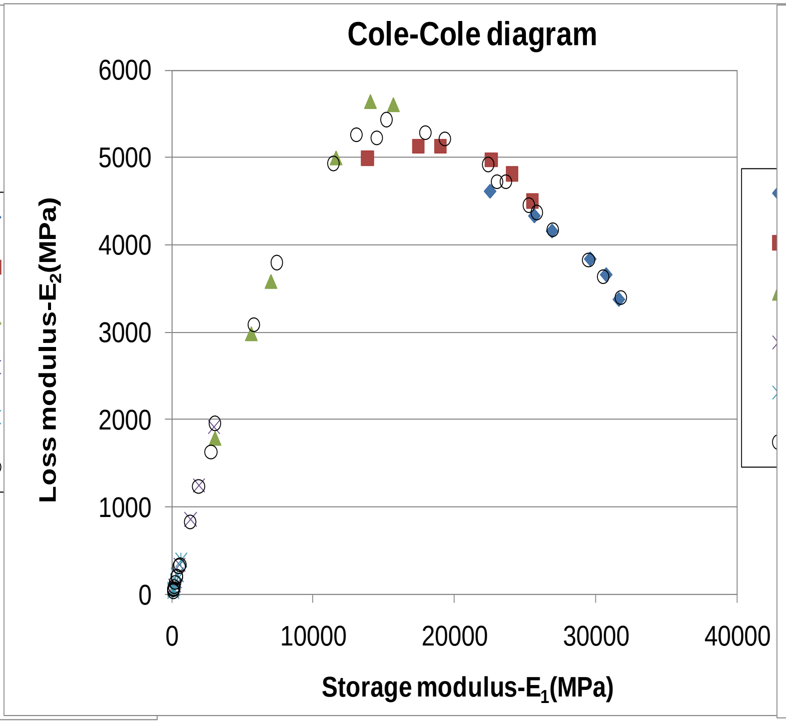
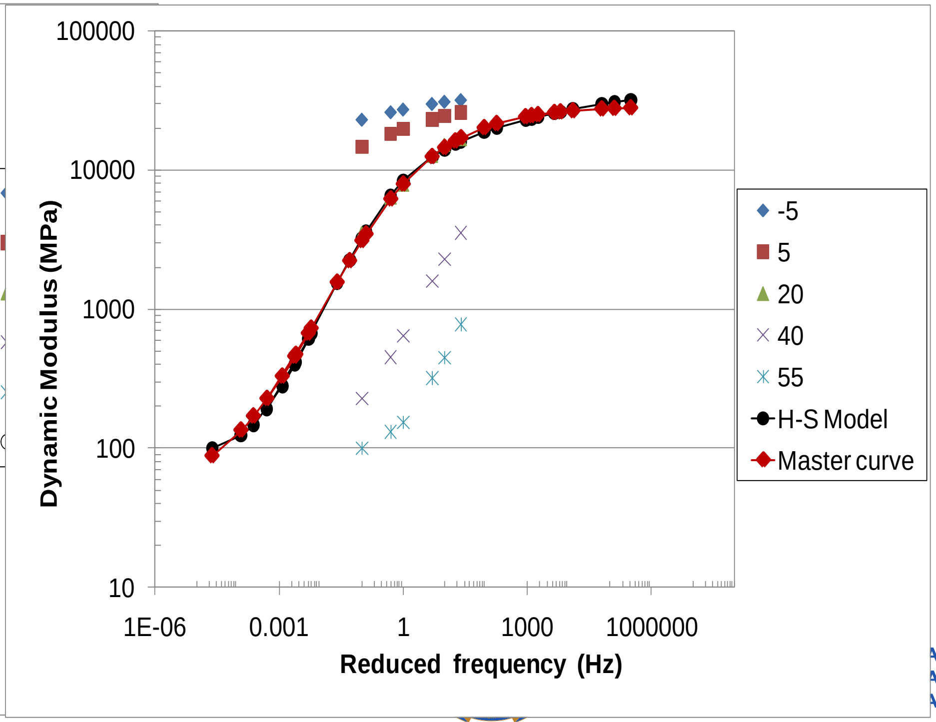
4. Materials models



Huet-Sayegh Model







4. Materials models

<u>Isotropic material</u>

E : constant elastic modulus

ν : constant Poisson's ratio

G : shear modulus

$$G = \frac{E}{2(1+\nu)}$$

<u>Cross-anisotropic material</u>

E_v : vertical elastic modulus

E_h : horizontal elastic modulus

G_{vh} : shear modulus

ν_v : vertical Poisson's ratio

ν_h : horizontal Poisson's ratio

5. Numerical Integration and its Challenges

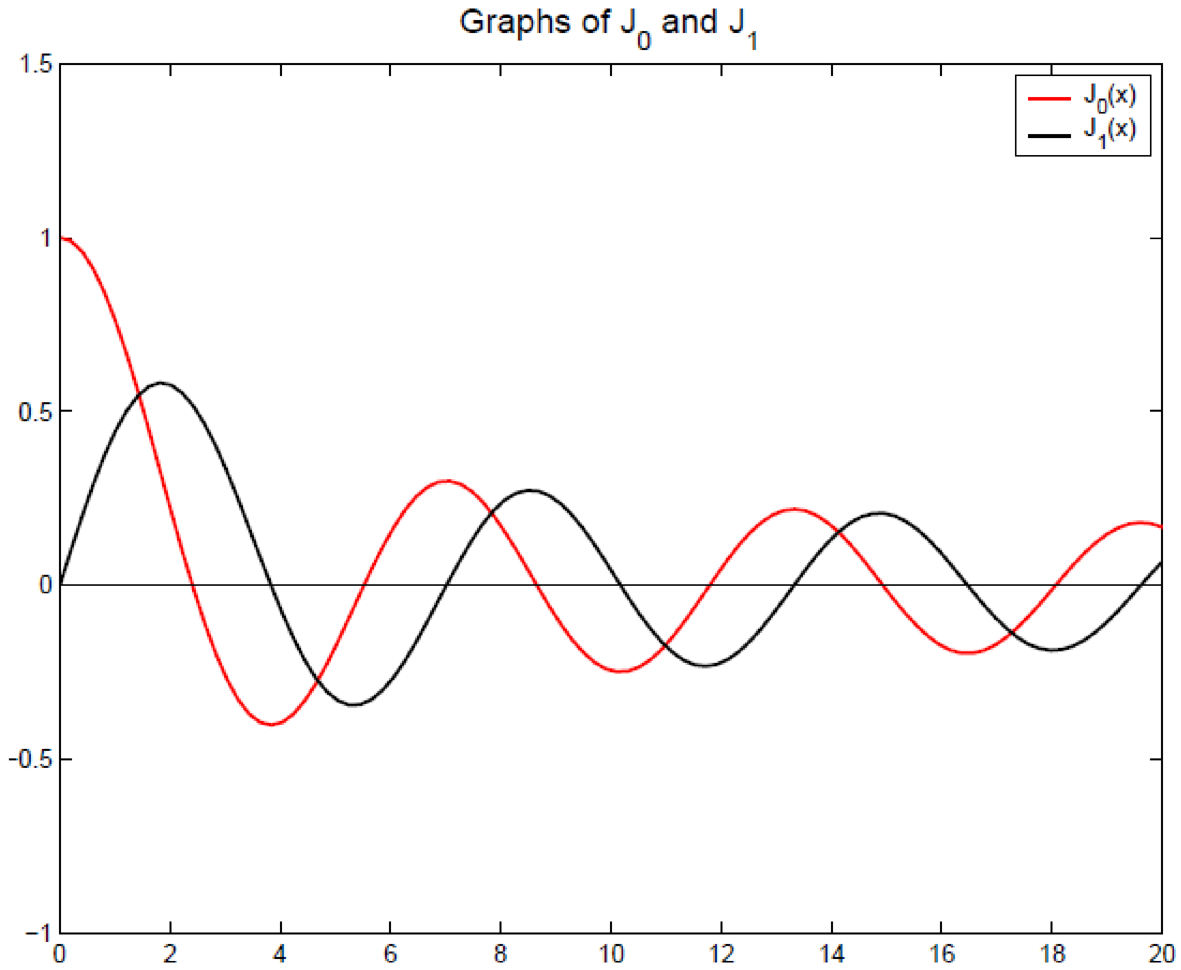
Hankel inverse transform of responses:

$$u_r = \int_0^\infty \xi \bar{u}_r J_1(\xi r) J_1(\xi a) d\xi$$

$$u_z = \int_0^\infty \xi \bar{u}_z J_0(\xi r) J_1(\xi a) d\xi$$

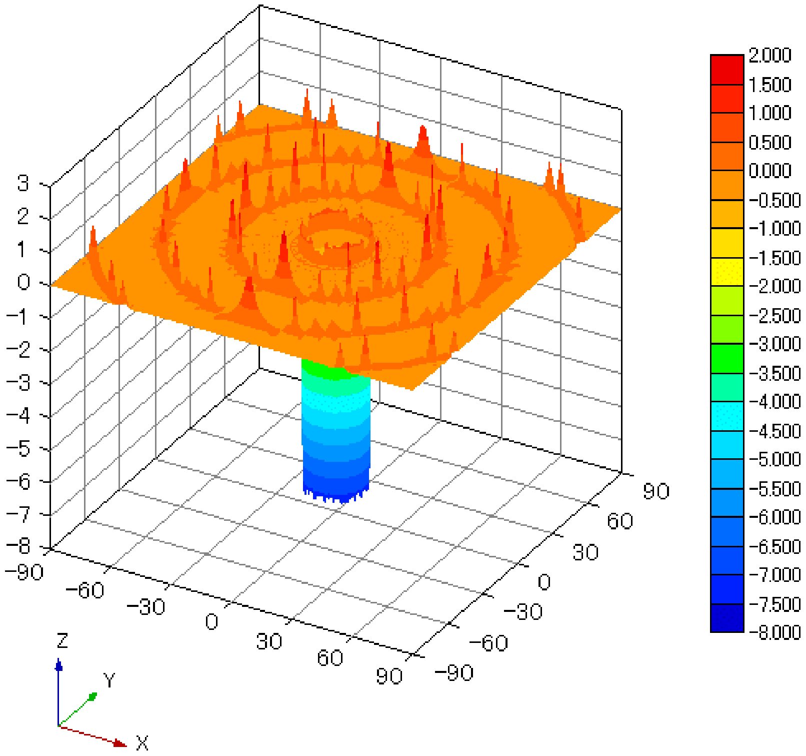
$$\sigma_z = \int_0^\infty \xi \bar{\sigma}_z J_0(\xi r) J_1(\xi a) d\xi$$

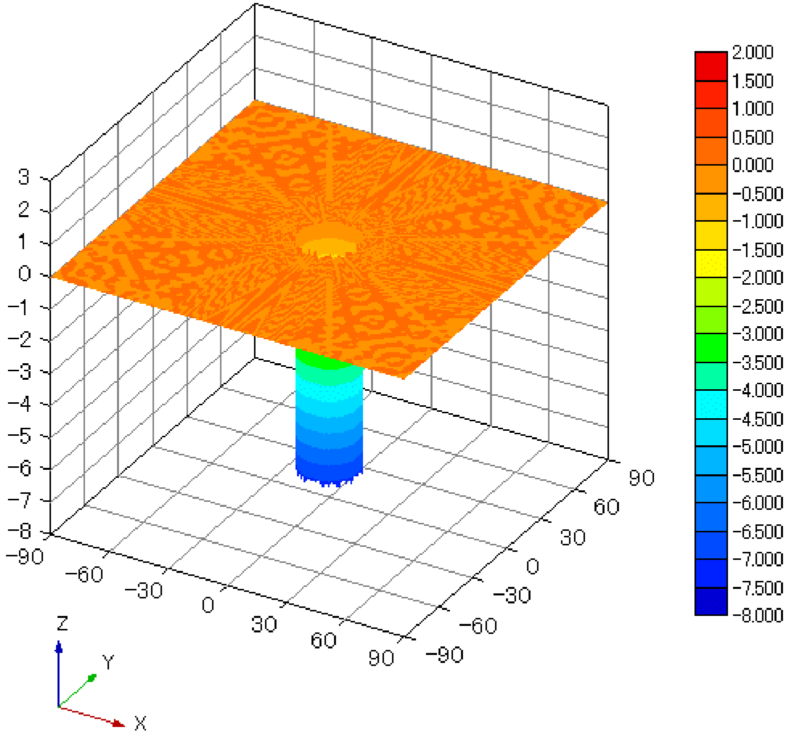
$$\tau_{rz} = \int_0^\infty \xi \bar{\tau}_{rz} J_1(\xi r) J_1(\xi a) d\xi$$



6. Efforts to improve speed and accuracy

3D plots of surface stress





Double Exponential (DE) Transforms

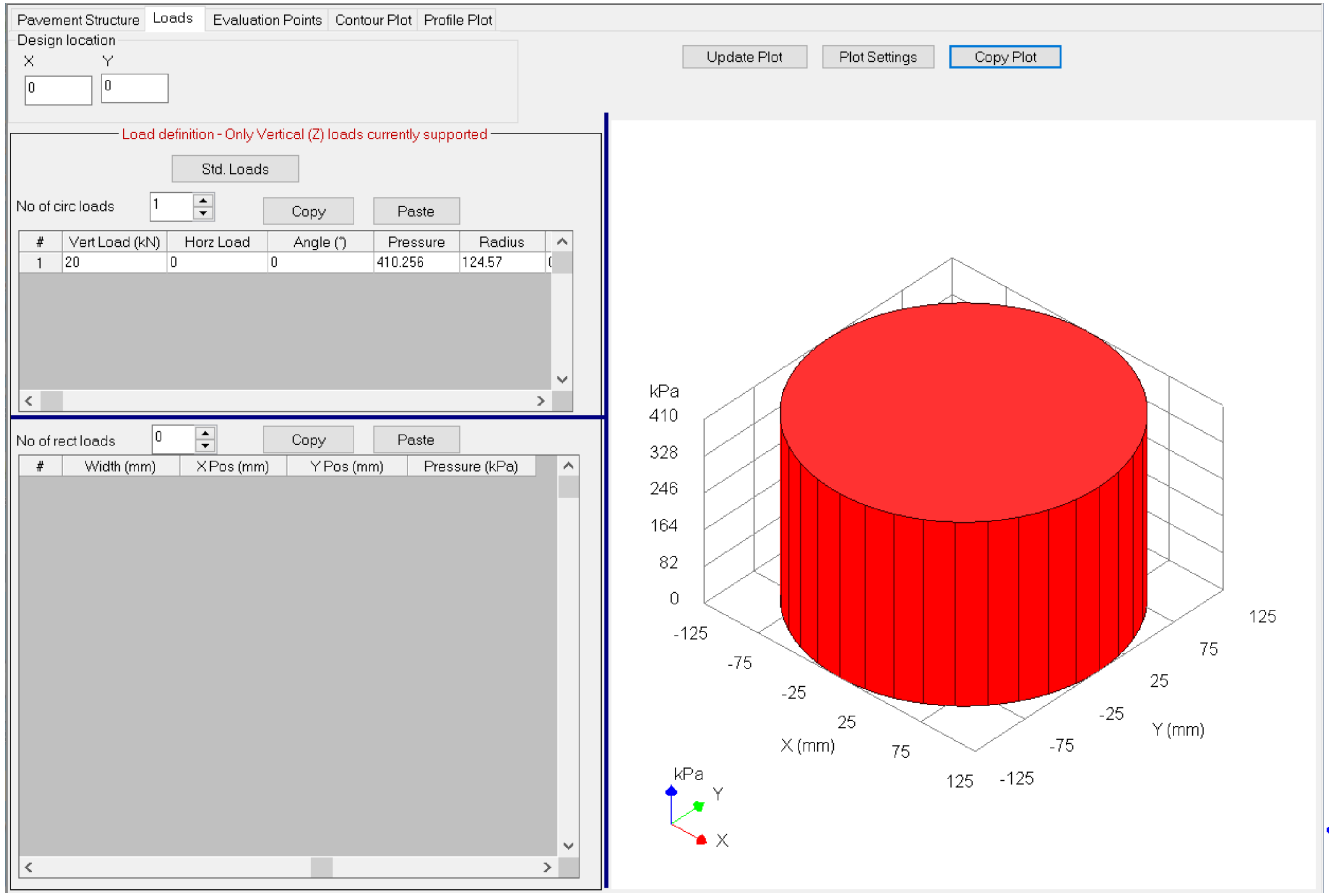
+

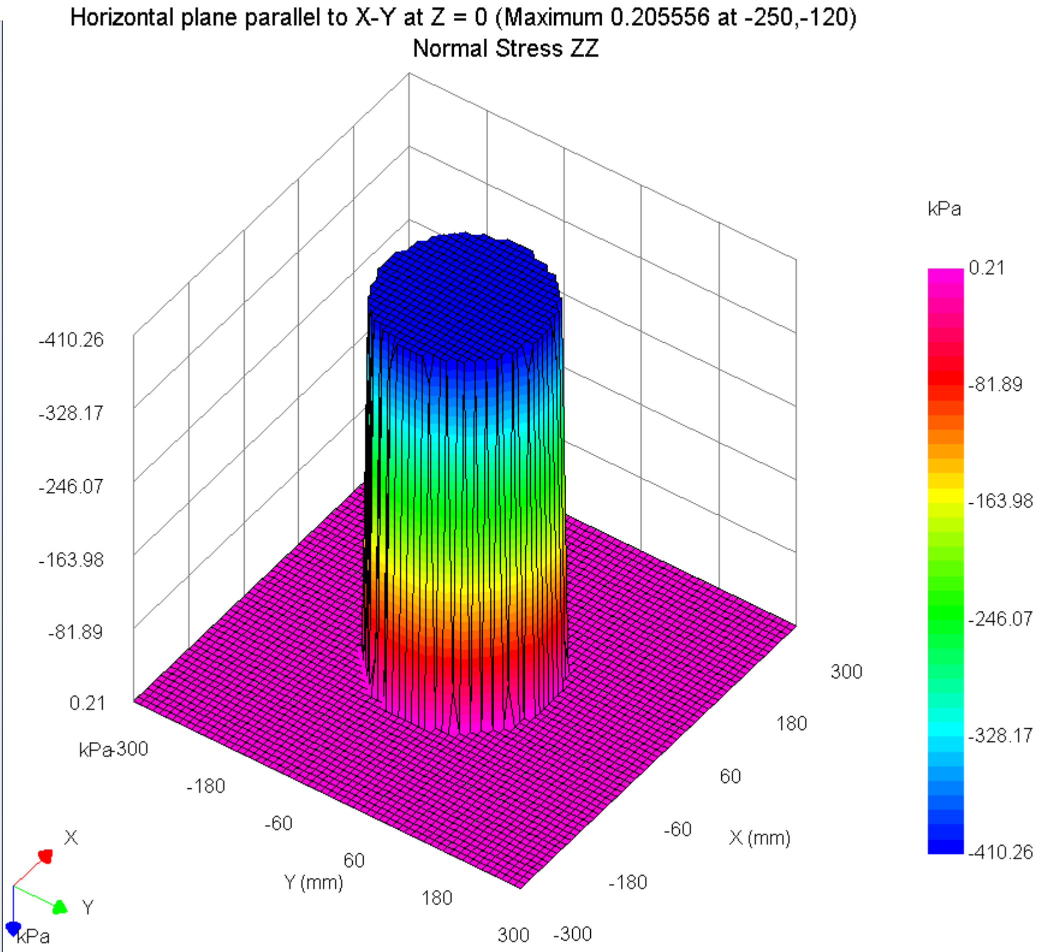
Richardson's extrapolation

$$I = \lim_{a \to 0} \int_0^\infty f(x) \exp\left(-ax^2\right) dx$$

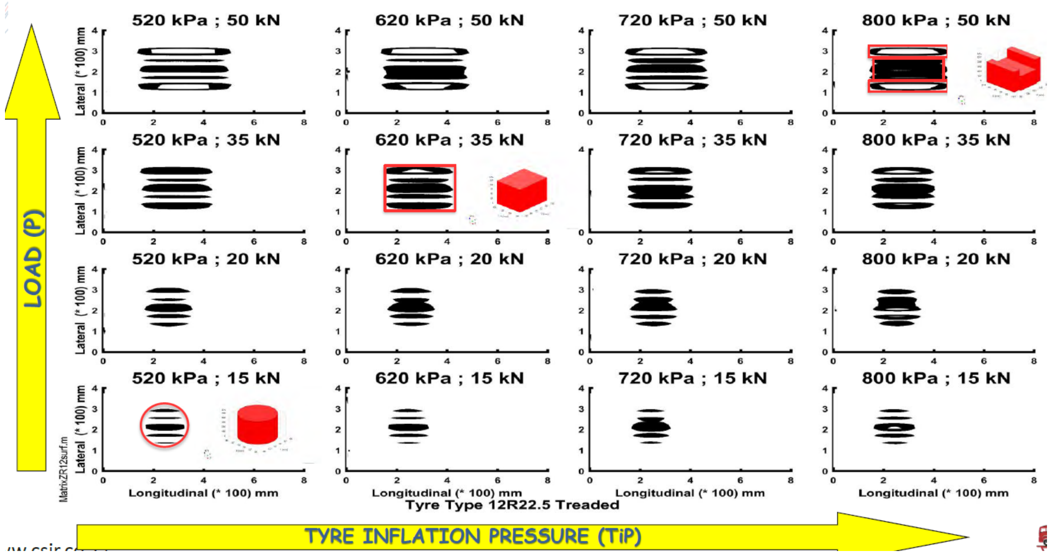
6. Efforts to improve speed and accuracy

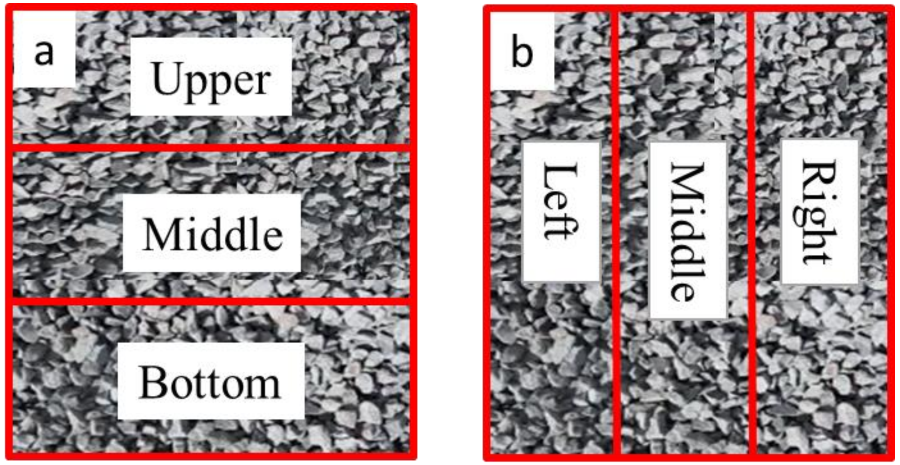
3D plots of surface stress

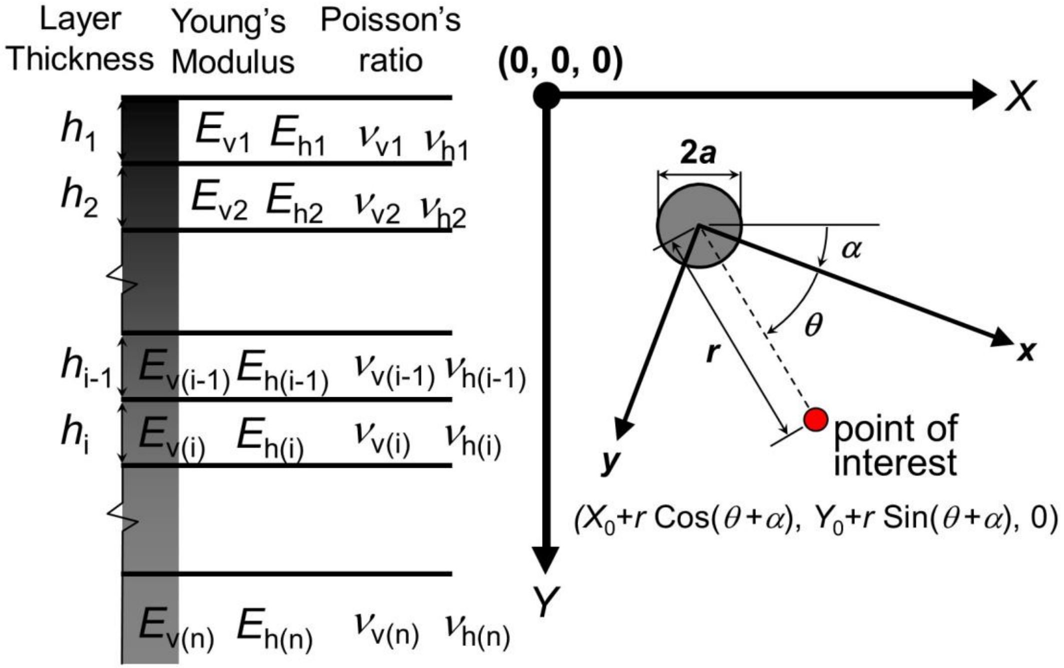


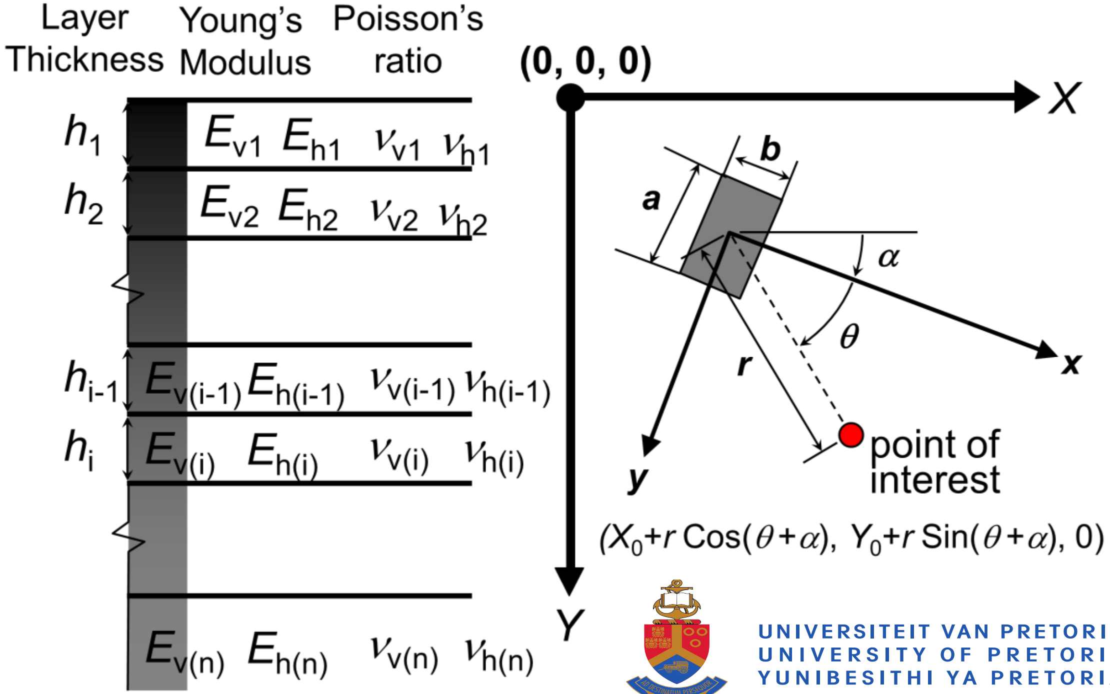


7. Some examples









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7. Some examples

Pavement Structure | Loads | Evaluation Points | Design Parameters | Pavement Life | Contour Plot | Profile Plot | Calculation Table

Number of Layers: 3 | Number of Phases: 1 | Default input: On | Cross-anistrophy On | Copy | Paste

#	Material	Thickness	E-modulus	E-modulus	Poisson's	Poisson's	Slip Rate	Density	Saturation
	Phase 1	(mm)	Ev (MPa)	Eh (MPa)	Muz (MPa)	Muh (MPa)	0-0.99	82-89 %	3-89 %
1	AC	150	5000	5000	0.44	0.44	0		
2	G2	150	450	450	0.35	0.35	0	86	30
3	Subgrade	0	100	100	0.35	0.35	0		

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2	G2	150	450	250	0.35	0.35	0	86	30
3	Subgrade	0	100	100	0.35	0.35	0		

7. Some examples

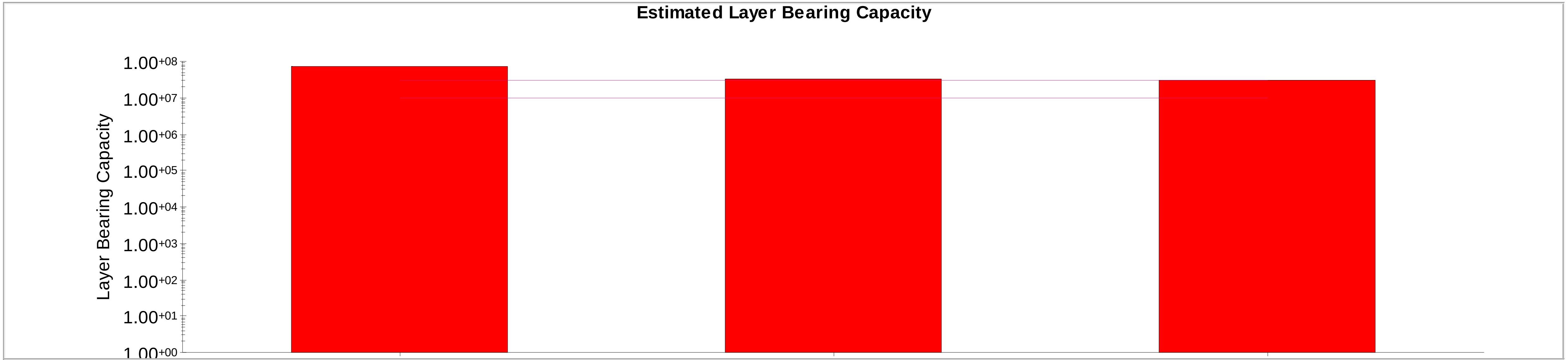
Transfer functions for HMA surfacing layers

$$\log N_f = I - S(\log \varepsilon_t) - offset$$

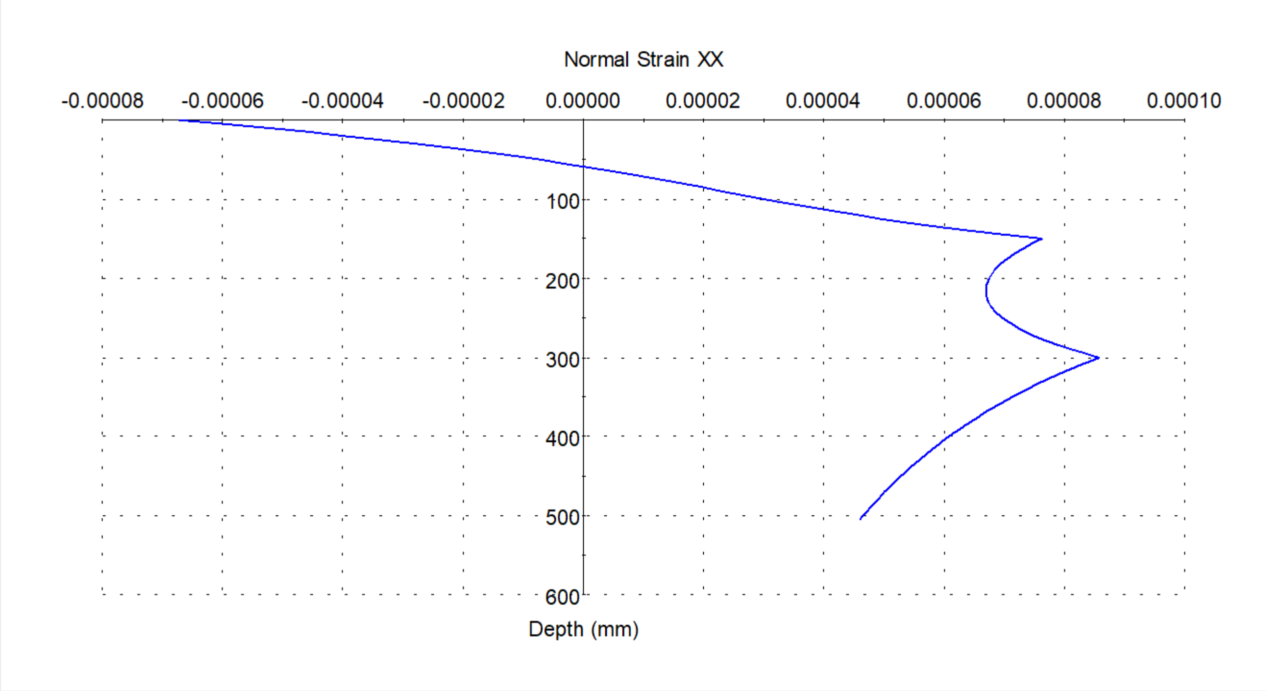
Material code	Intercept	Slope	Offsets 50%	Offsets 80%	Offsets 90%	Offsets 95%
AC	18.114	5.195	0	0.242	0.352	0.469
AG	17.725	4.774	0	0.382	0.425	0.437

Reset | OK | Cancel | Help

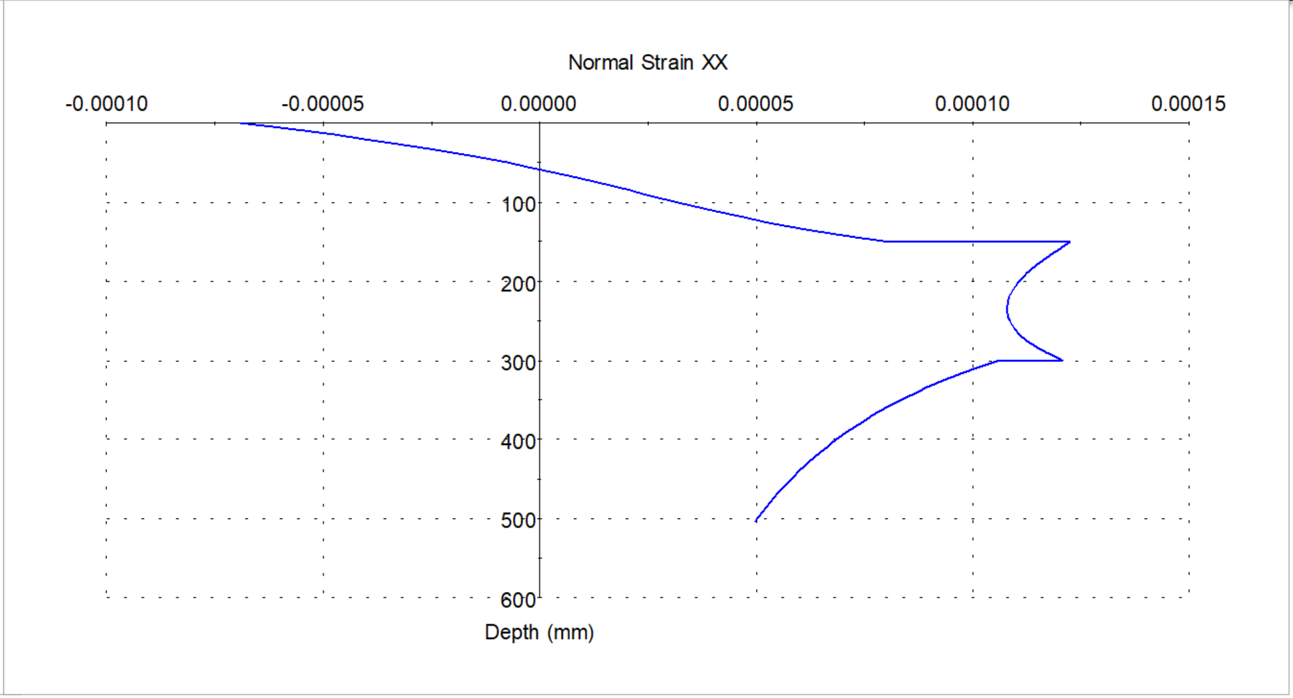
7. Some examples



7. Some examples



Isotropic base-layer



Transversely-Isotropic base-layer

8. CONCLUDING REMARKS

- A partnership between industry and academia/research council is important
- Information from the laboratories and field are important for realistic numerical modelling of pavement structures
- Computation power is available at reasonable cost for realistic pavement modelling and analysis
- With the support from industry, academia/research council have the skills and capability to develop user friendly and powerful tools for M-E pavement design and analysis.