Road Directorate

Performance Prediction Models in MMOPP

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MMOPP

- Mathematical Modelling of Pavement Performance

- Design at three levels:
  - Pavement catalogue
  - Analytical-empirical method
  - Simulation and optimisation

Design by simulation

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- Models for:
  - Pavement: longitudinal profile, thicknesses, E-values
  - Load: reaction between wheel and pavement
  - Climate: temperature and E-value
  - Pavement response: stress, strain, deflection
  - Asphalt deterioration
  - Permanent deformation

Design by simulation

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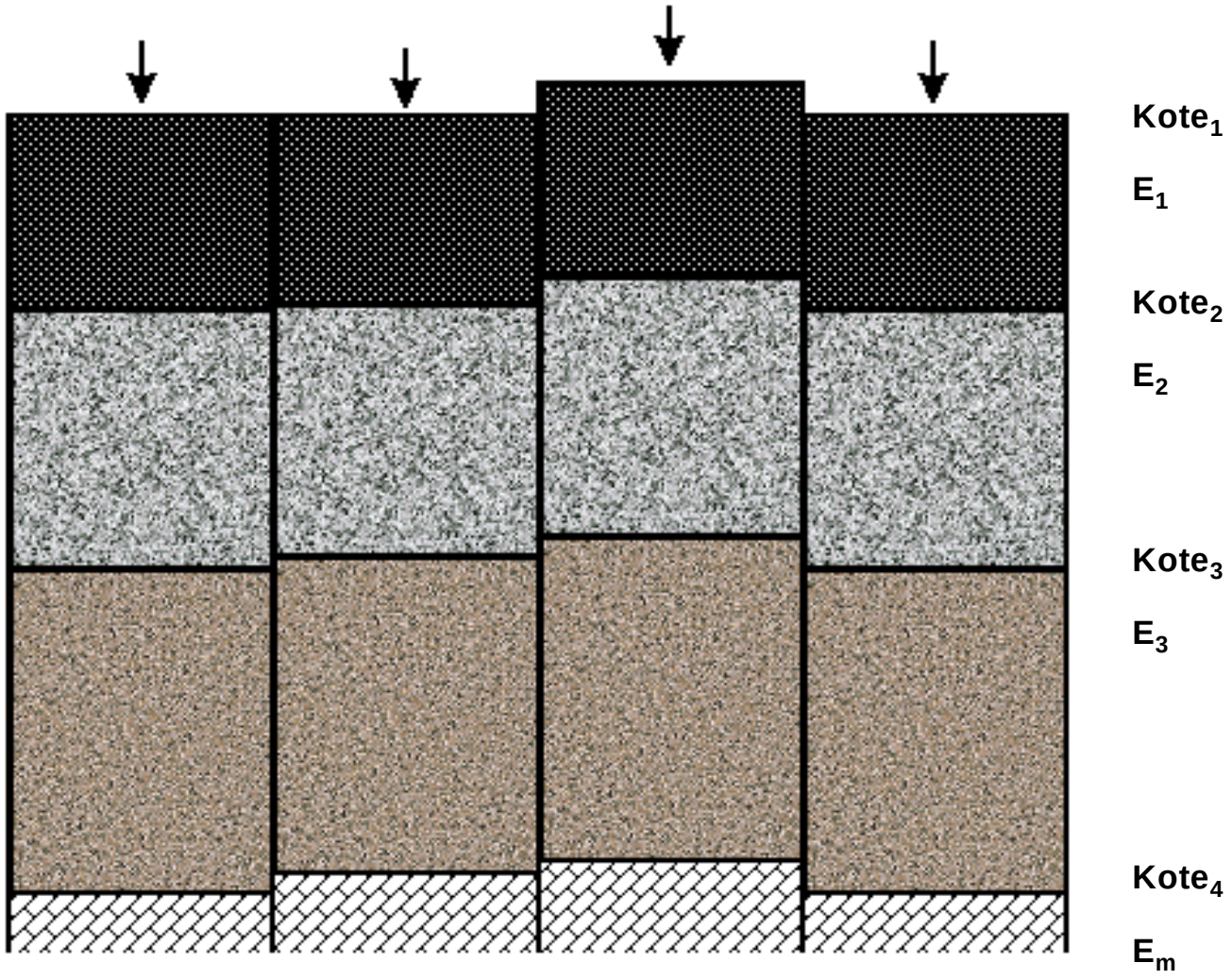
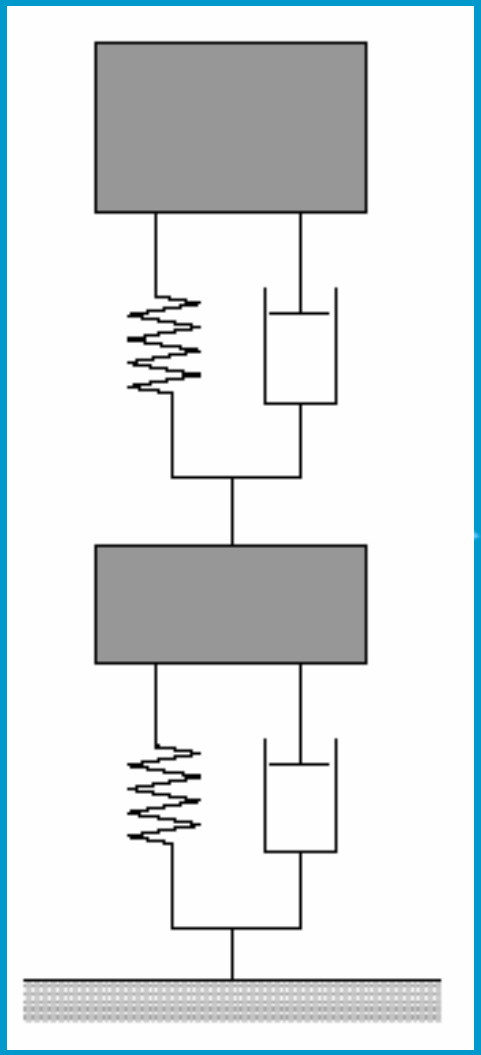


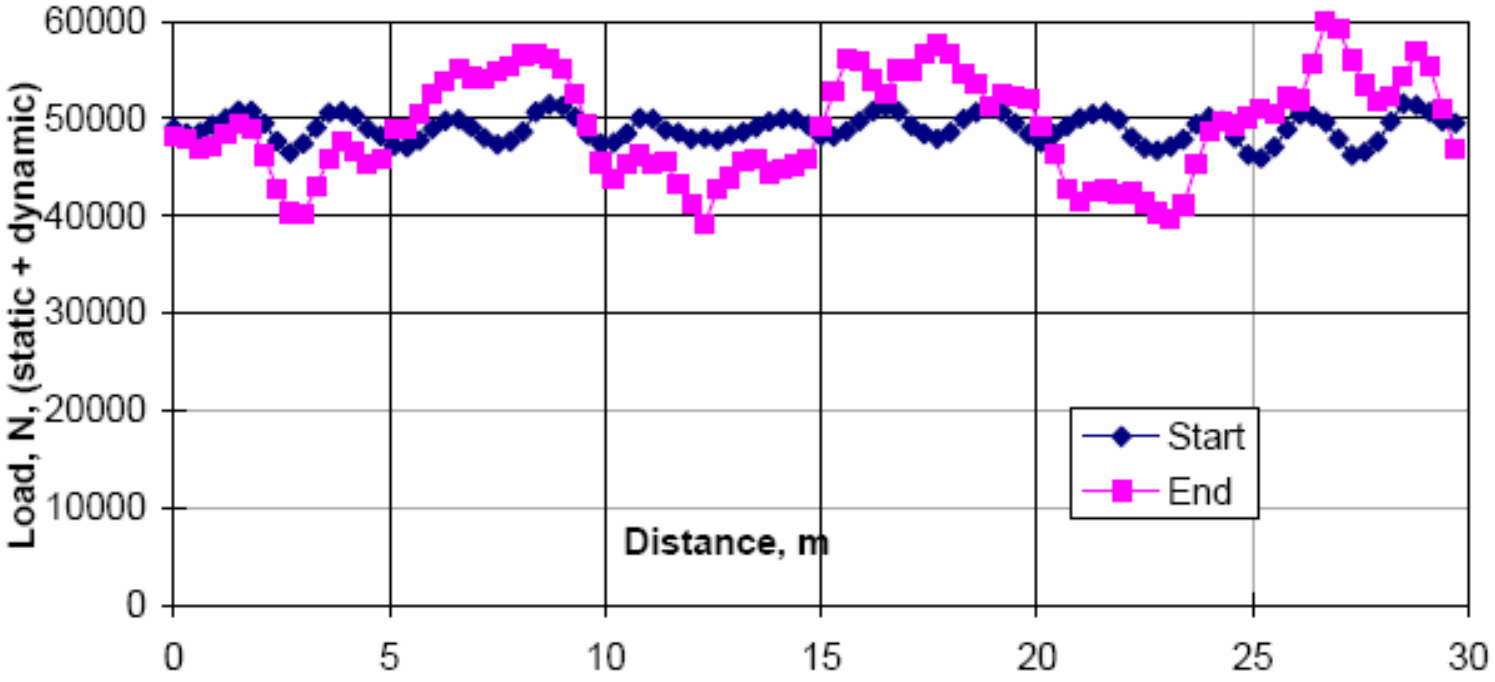
Load simulation



Suspension system

Axle and wheel

Variation of load



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Climate model

- Material E moduli in different climate seasons
- Depth of frost penetration

Climate seasons

Period	Days	Temperature	E_1	E_2	E_3	E_m
-	-	°C	factor	factor	factor	factor
Winter	49	-2	4	4.2	10	20
Winter thaw	10	1	3.7	0.33	10	20
Spring thaw	15	1	3.7	0.67	0.7	0.6
Late spring	46	4	3.1	1.0	0.85	0.8
Summer	143	20	1.0	1.0	1.0	1.0
Heat wave	10	50	0.3	1.0	1.0	1.0
Fall	92	7	2.6	1.0	1.0	1.0

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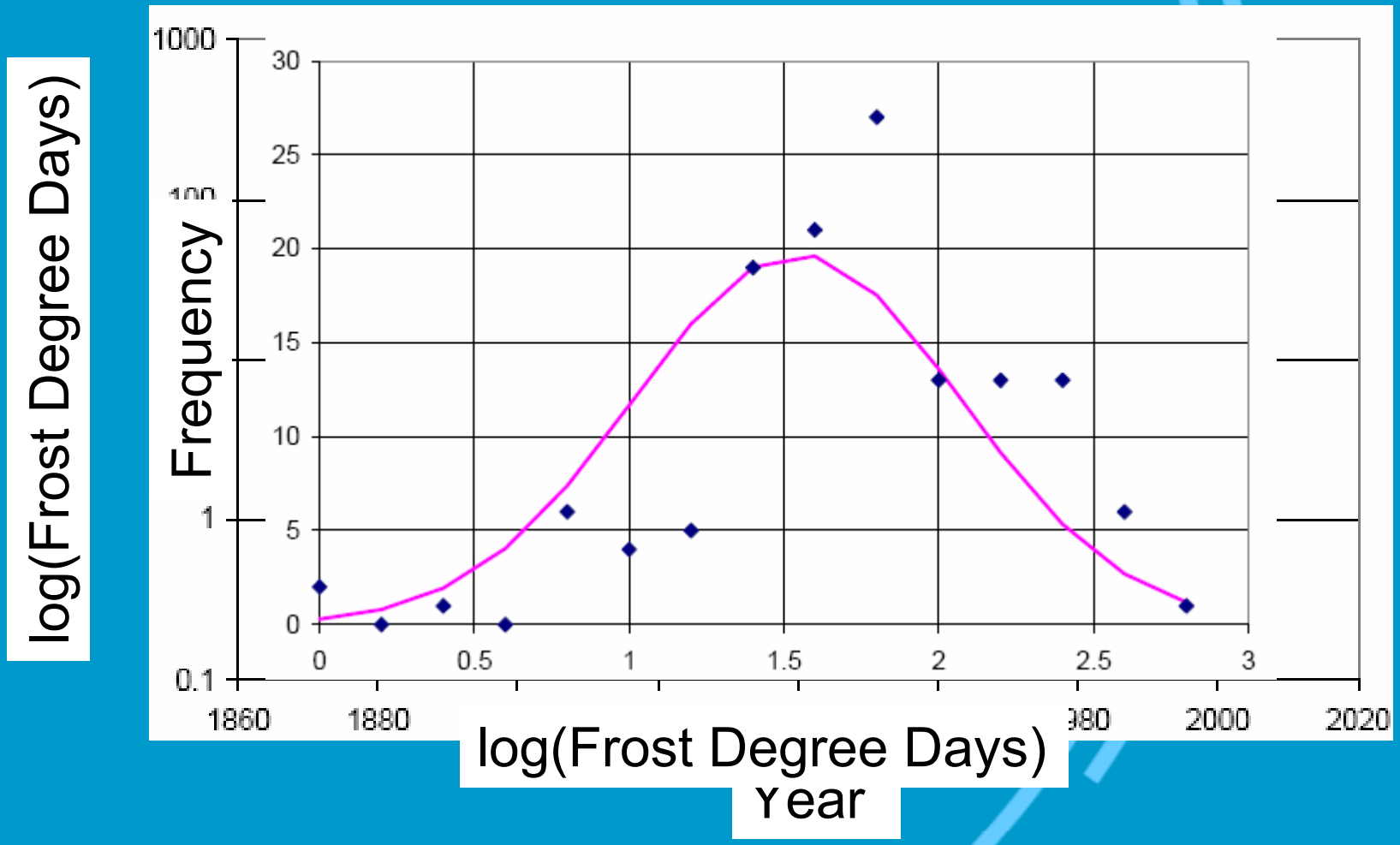
Climate model



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Response model

- Method of Equivalent Thicknesses
- 4-layer system

Structural deterioration (crackring)

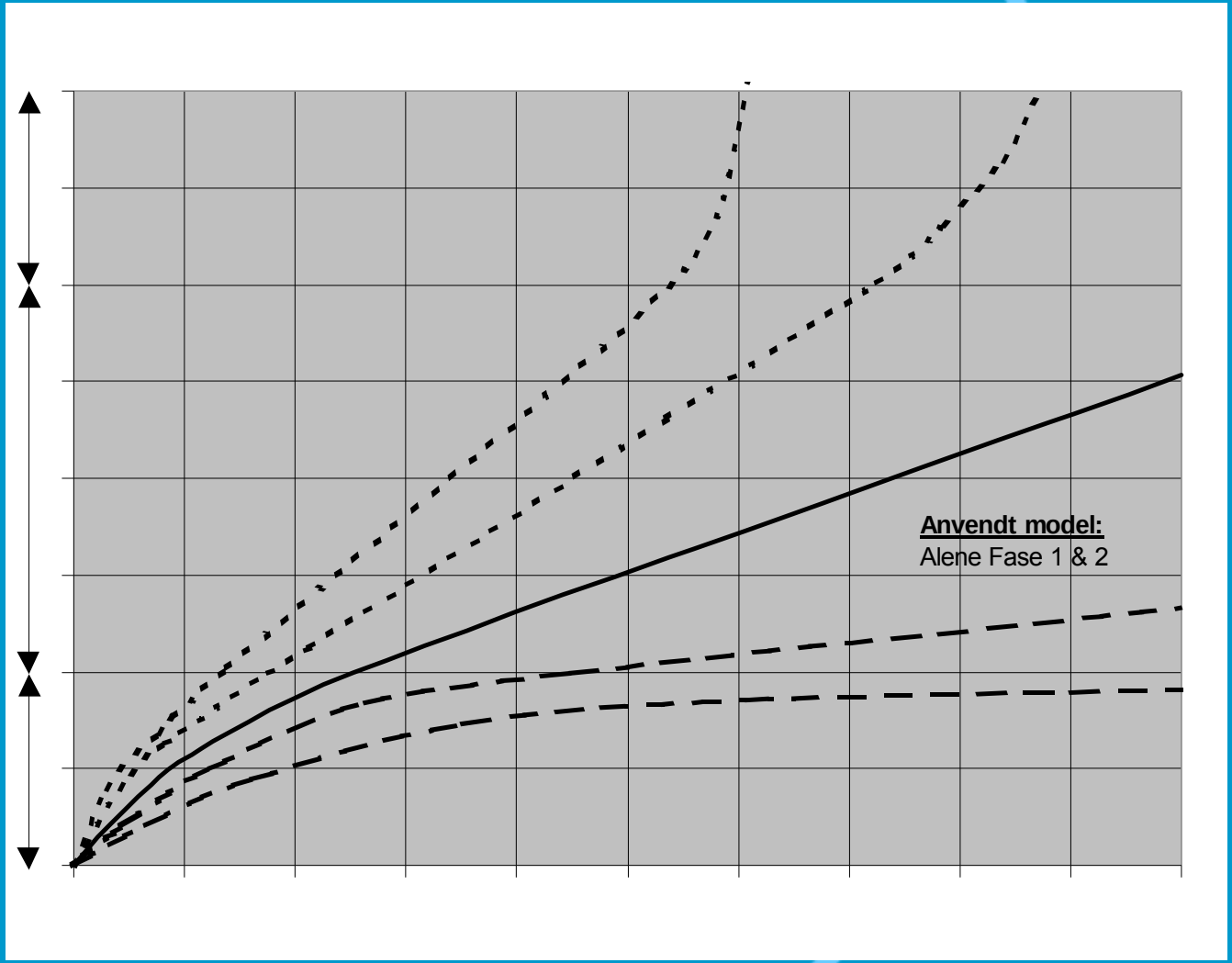
$$E_{after} = E_{before}\left(1 - 0{,}5\left(\frac{\varepsilon_{calc}}{\varepsilon_{allowble,1million}(VB/10\%)}\right)^{n}\frac{dN}{K_{temperature}CP_{factor}}\right)$$

Permanent deformation

Phase 3
Increasing strain rate

Phase 2
Constant strain rate

Phase 1
Decreasing strain rate



Plastic strain models

Phase 1

(for $\varepsilon_p < \varepsilon_0$)

$$\varepsilon_p = AN^B\left(\frac{\sigma_1}{\sigma'}\right)^C$$

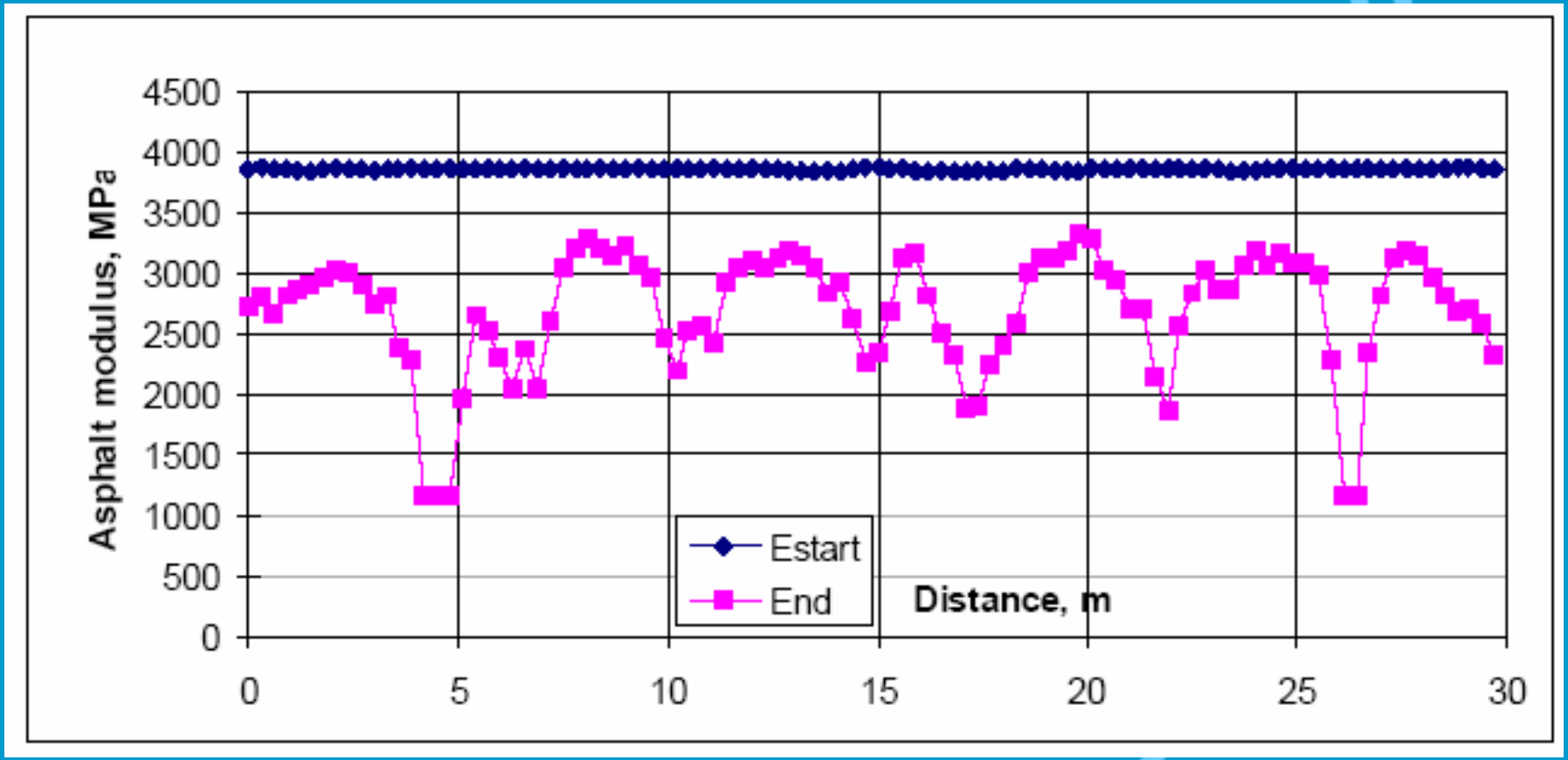
Phase 2

(for $\varepsilon_p > \varepsilon_0$)

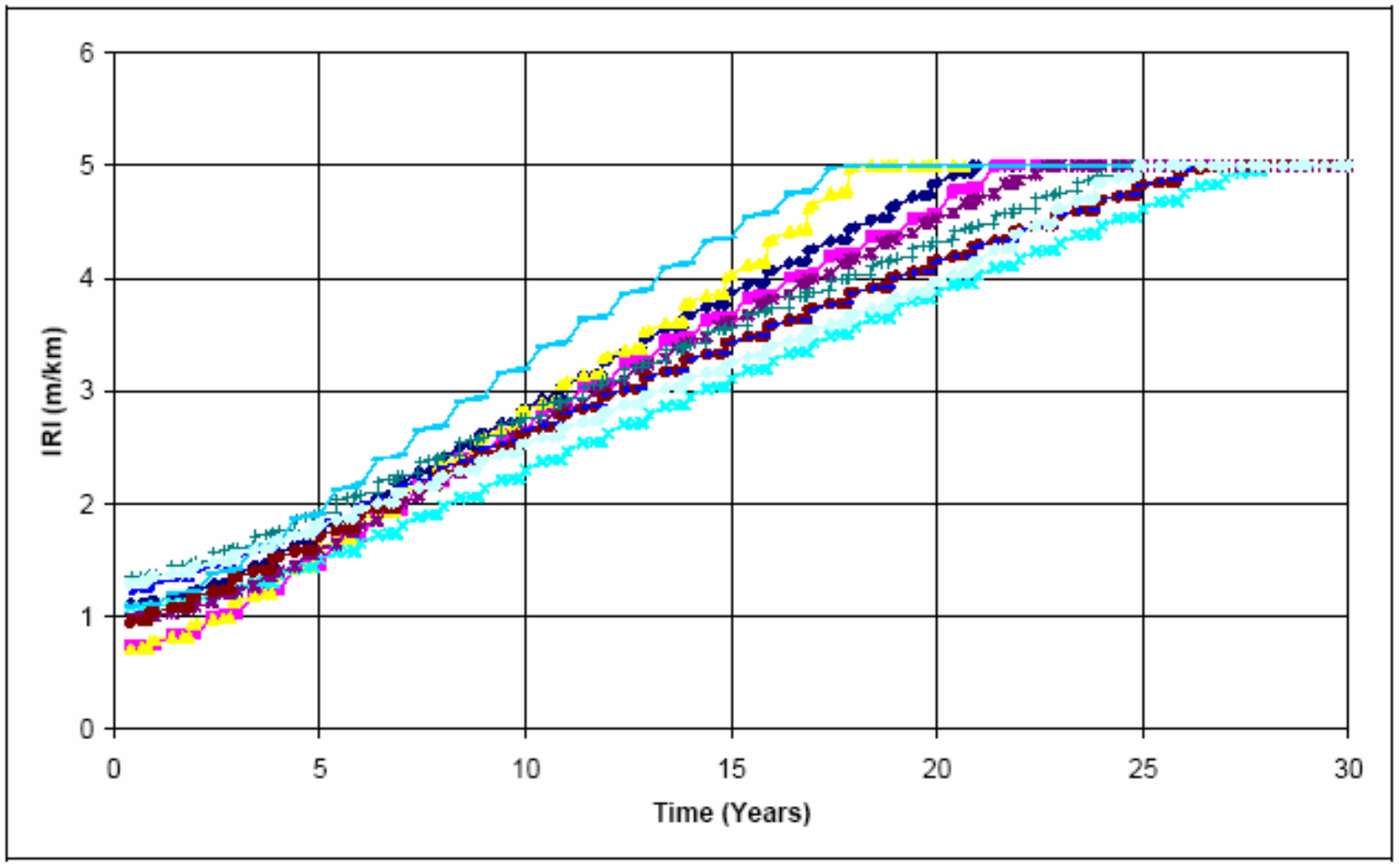
$$\varepsilon_p = \varepsilon_0 + \left(N - N_0\right)A^{\frac{1}{B}}B\varepsilon_0^{1-\frac{1}{B}}\left(\frac{\sigma_1}{\sigma'}\right)^{\frac{C}{B}}$$

$$N_0 = \varepsilon_0^{\frac{1}{B}}A^{\frac{-1}{B}}\left(\frac{\sigma_1}{\sigma'}\right)^{\frac{-C}{B}}$$

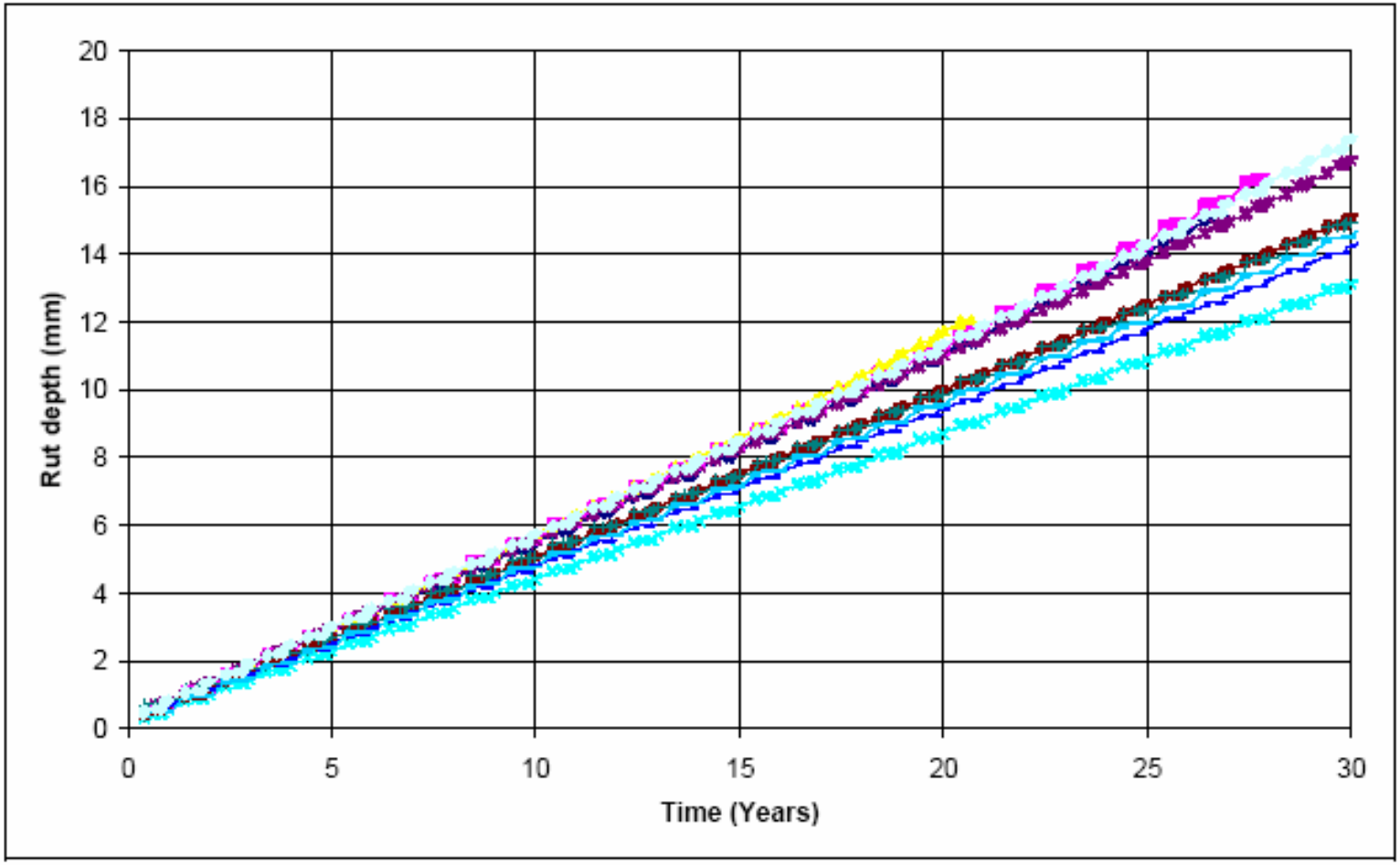
Asphalt modulus variation



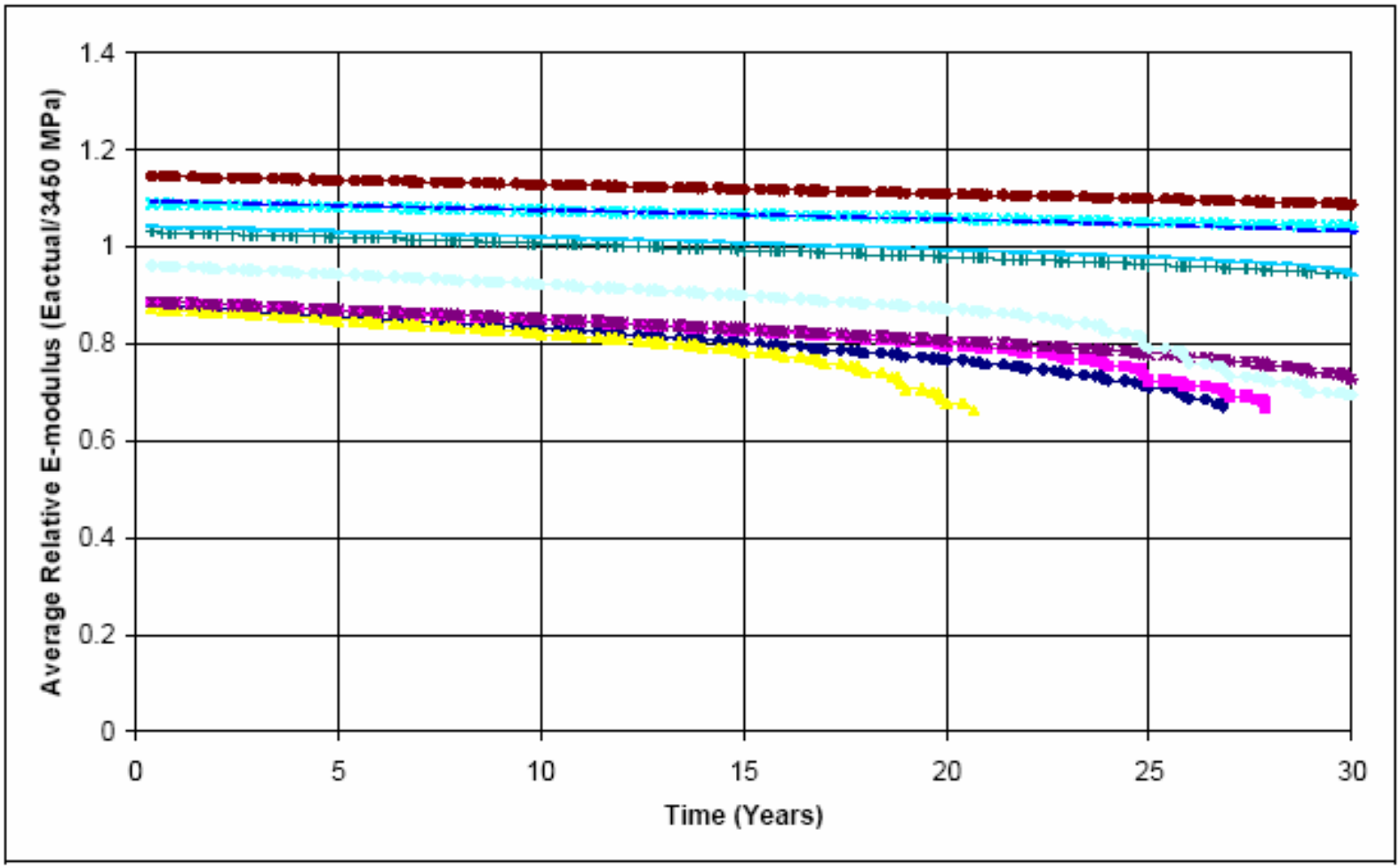
Roughness variation



Rut depth development



Relative asphalt modulus



Roughness development - 1

Roughness development - 2