

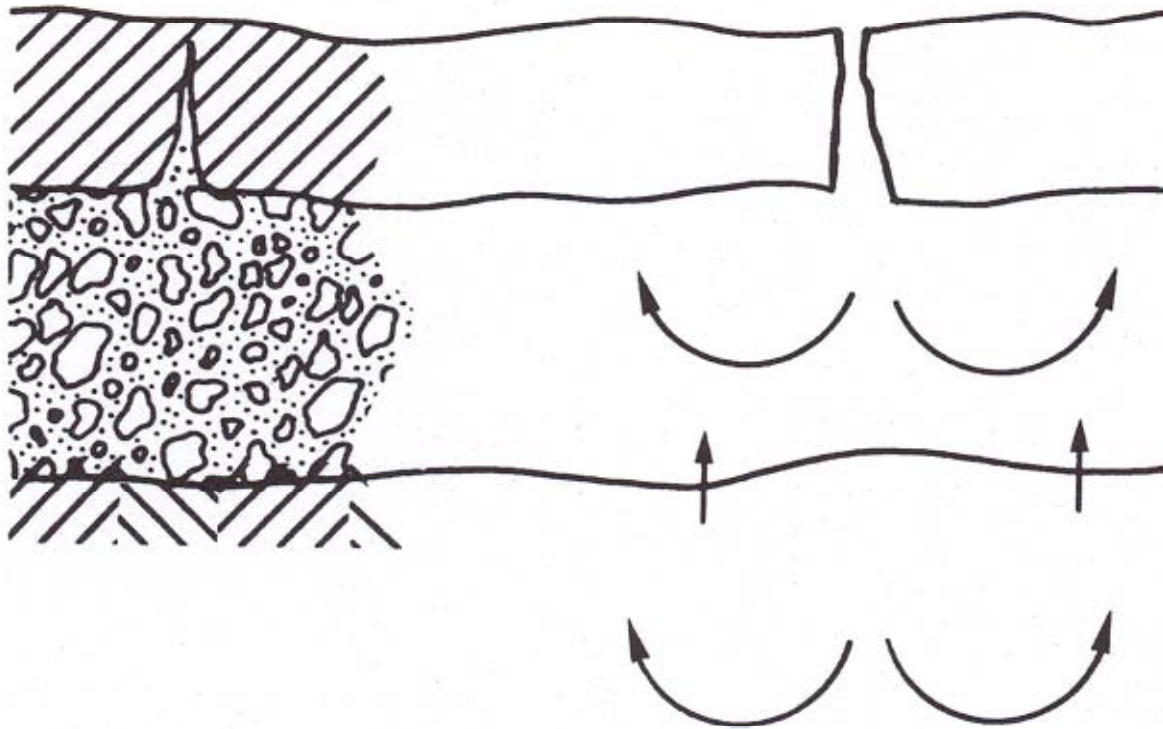


Performance

Per Ullidtz
Dynatest International



2 Empirical



PERFORMANCE
(STRUCTURAL & FUNCTIONAL)



Classical

- ◆ ESAL
- ◆ Weighted average annual condition
- ◆ Damage based on initial response

Damage functions

- ◆ Full load spectrum
- ◆ Seasonal variations
- ◆ Incremental-recursive damage calculation



$$N = k_1 \times \varepsilon^{k_2} \times E^{k_3}$$

$$MN_p = \left(\frac{resp}{resp_{ref}} \right)^\beta \times \left(\frac{E}{E_{ref}} \right)^\gamma$$

$$resp_p = resp_{ref} \times MN^{1/\beta} \times \left(\frac{E}{E_{ref}} \right)^{-\gamma/\beta}$$



The Asphalt Institute

$$N = 18.4 \times C \times 4.325 \times 10^{-3} \times \varepsilon_t^{-3.29} \times |E^*|^{-0.854}$$

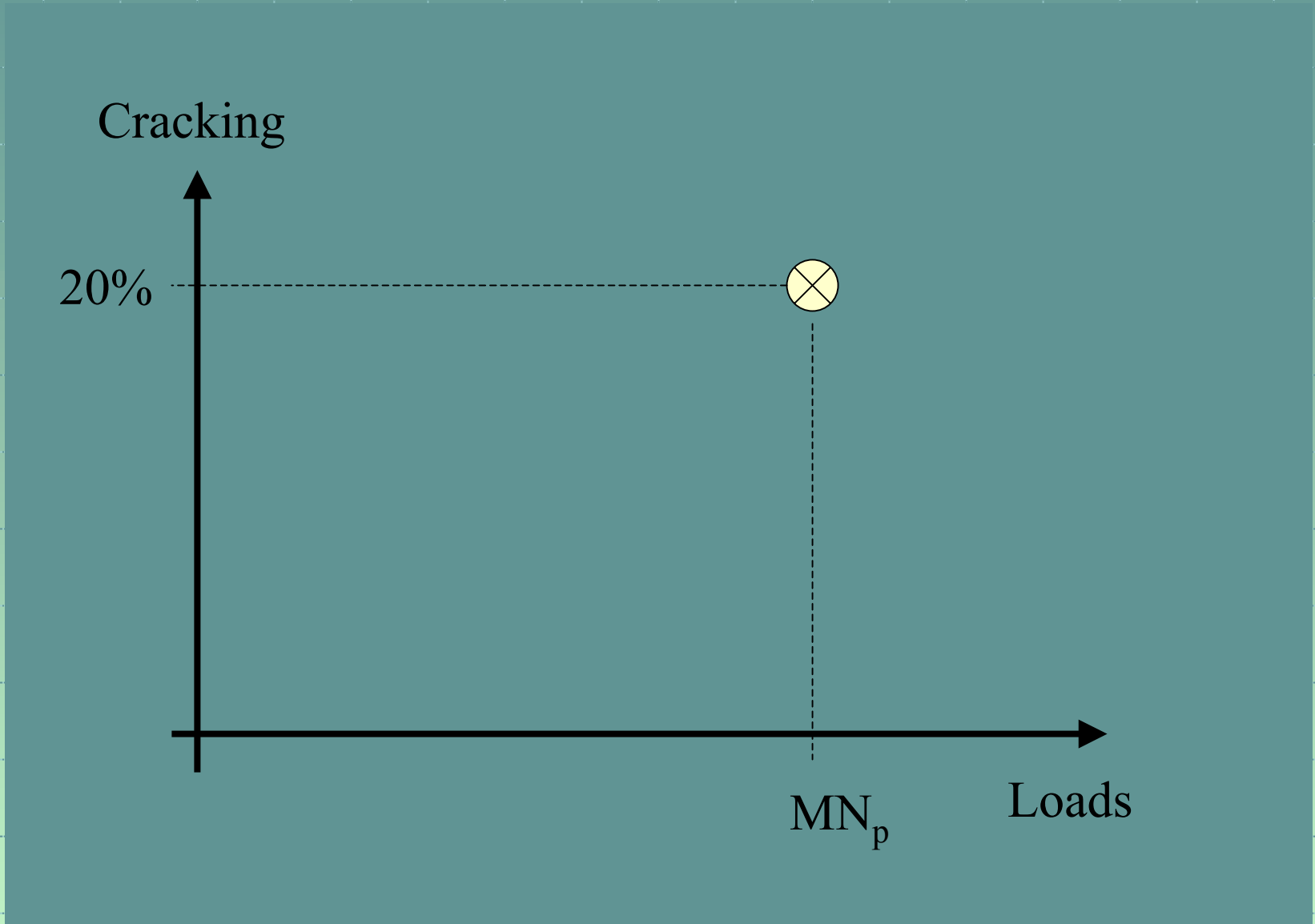
$$C = 10^M$$

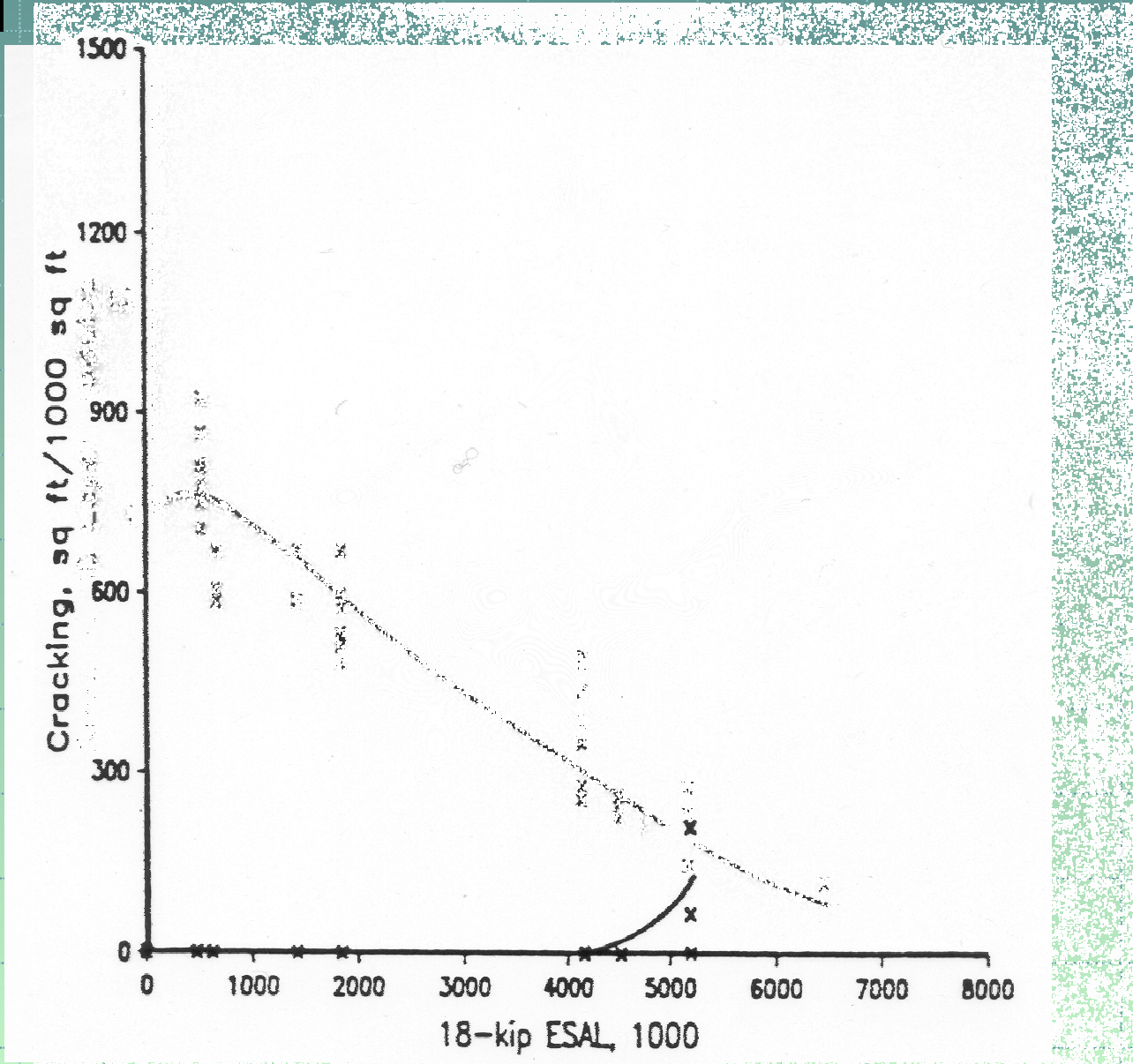
$$M = 4.84 \times \left(\frac{V_b}{V_v + V_b} - 0.69 \right)$$

$\geq 20\%$ *fatigue cracking, total area*



$$MN_p = \left(\frac{\mu \varepsilon}{239 \times C^{1/3.29}} \right)^{-3.29} \times \left(\frac{E}{3000 \text{ MPa}} \right)^{-0.854}$$







$$\text{Damage} = dE/E_i$$

0.7

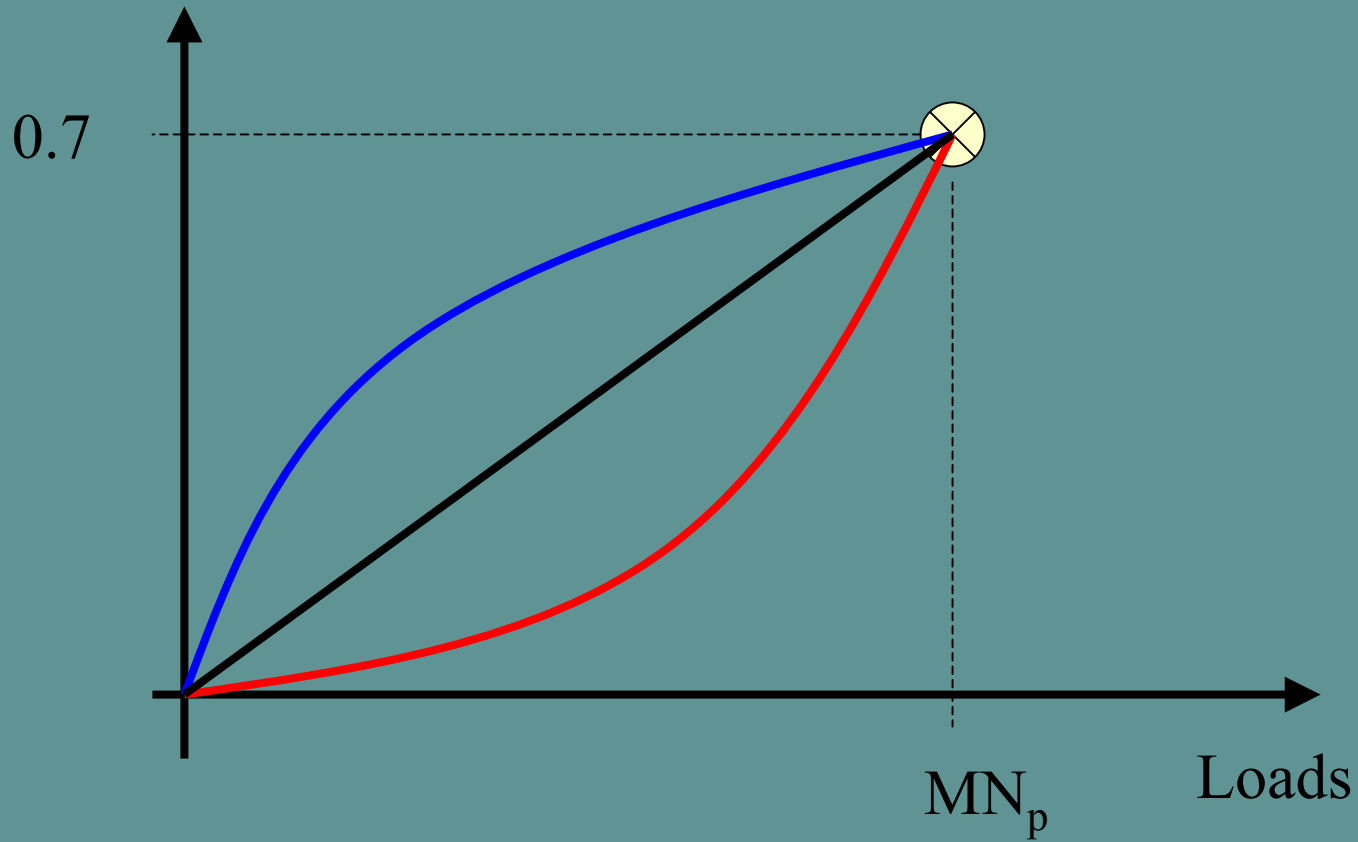


MN_p

Loads



$$\text{Damage} = dE/E_i$$





$$Damage = Dam_p \times \left(\frac{MN}{MN_p} \right)^\alpha$$



$$Dam = Dam_p \times \left(MN \times \left(\frac{resp}{resp_{ref}} \right)^{-\beta} \times \left(\frac{E}{E_{ref}} \right)^{-\gamma} \right)^{\alpha}$$

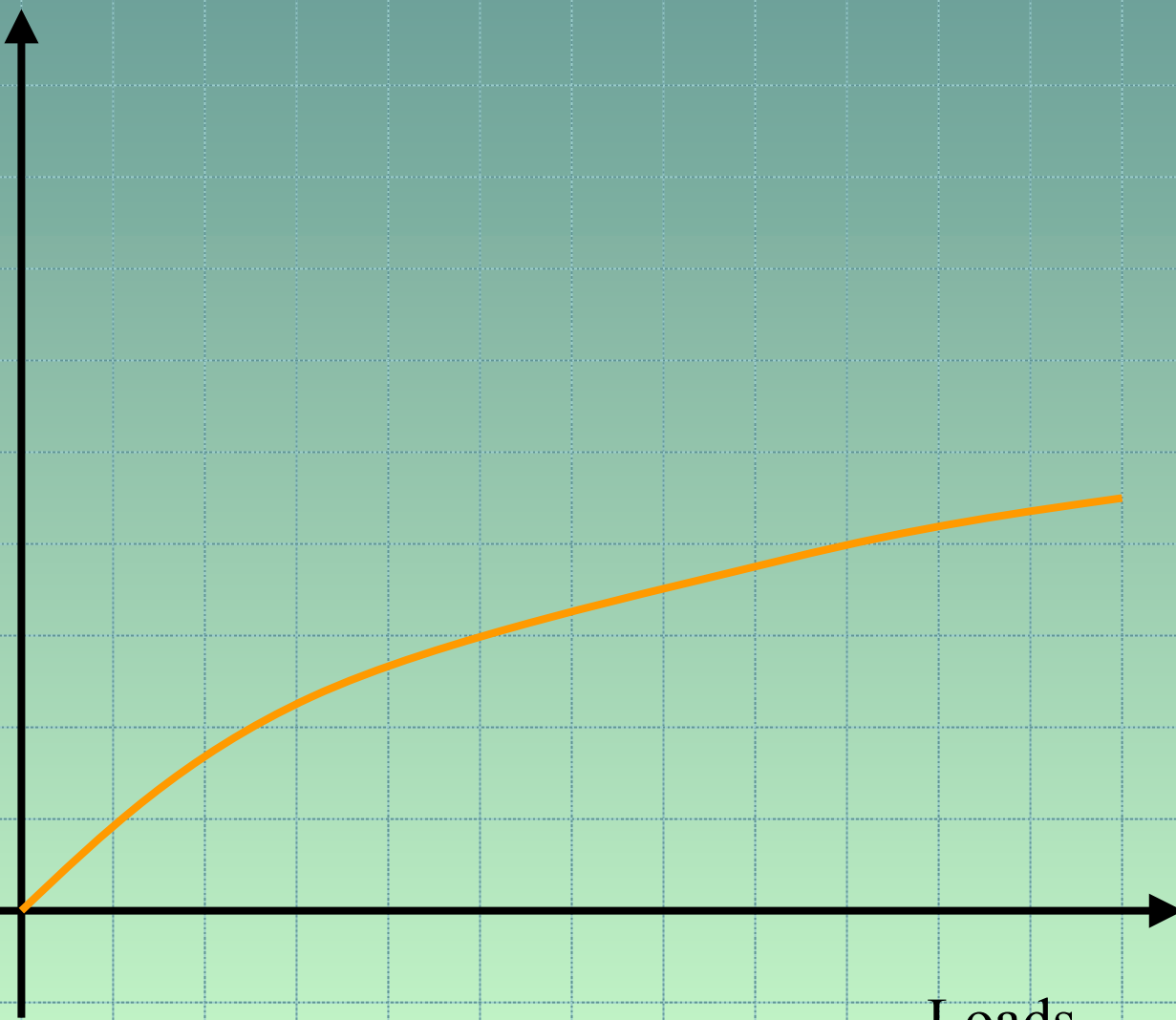


The Asphalt Institute

$$Dam = 0.7 \times \left(MN \times \left(\frac{\mu \varepsilon}{239 \times C^{1/3.29}} \right)^{3.29} \times \left(\frac{E}{3000 \text{ MPa}} \right)^{0.854} \right)^\alpha$$



Damage



Loads

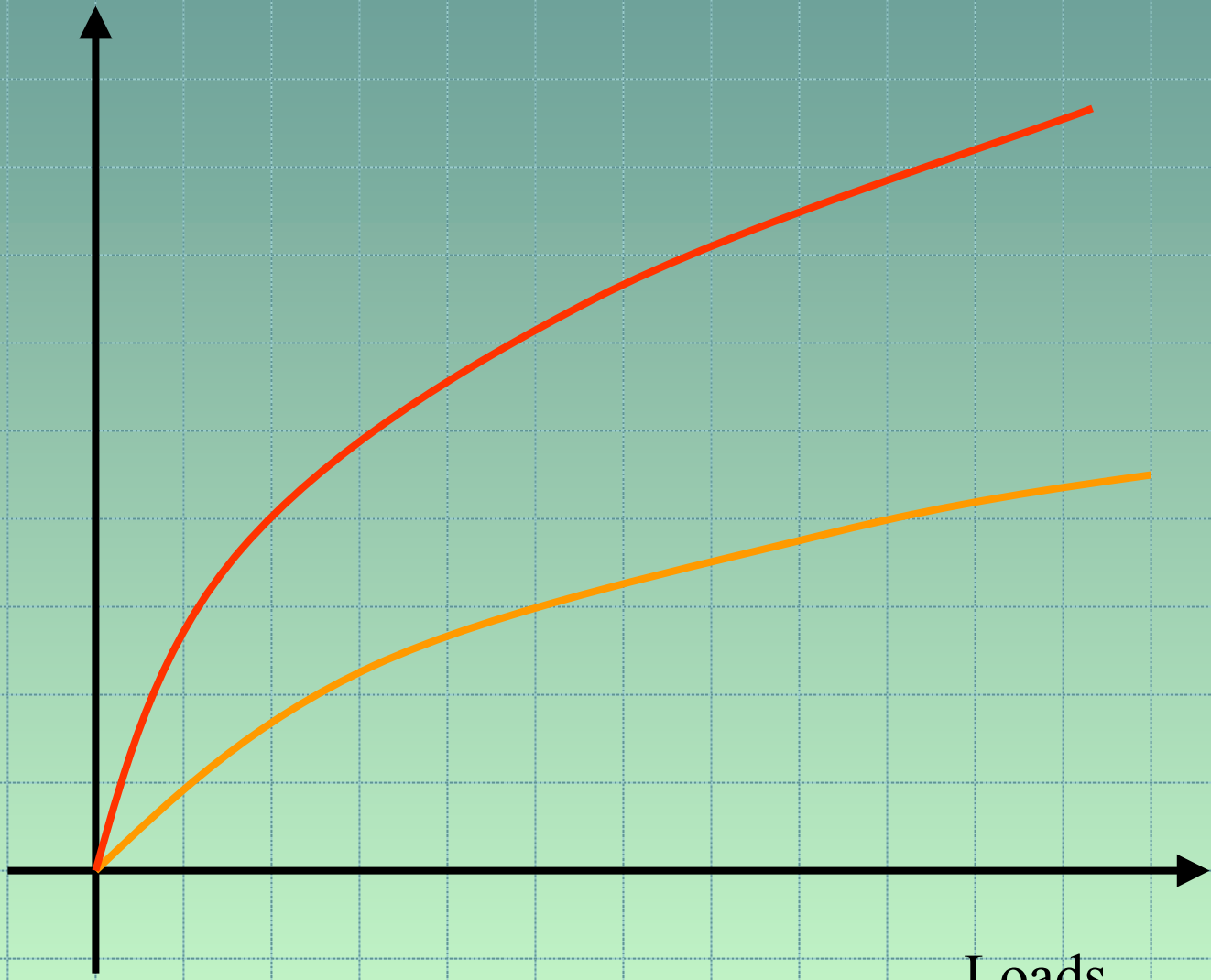
13/05/2003

Performance

14



Damage



Loads

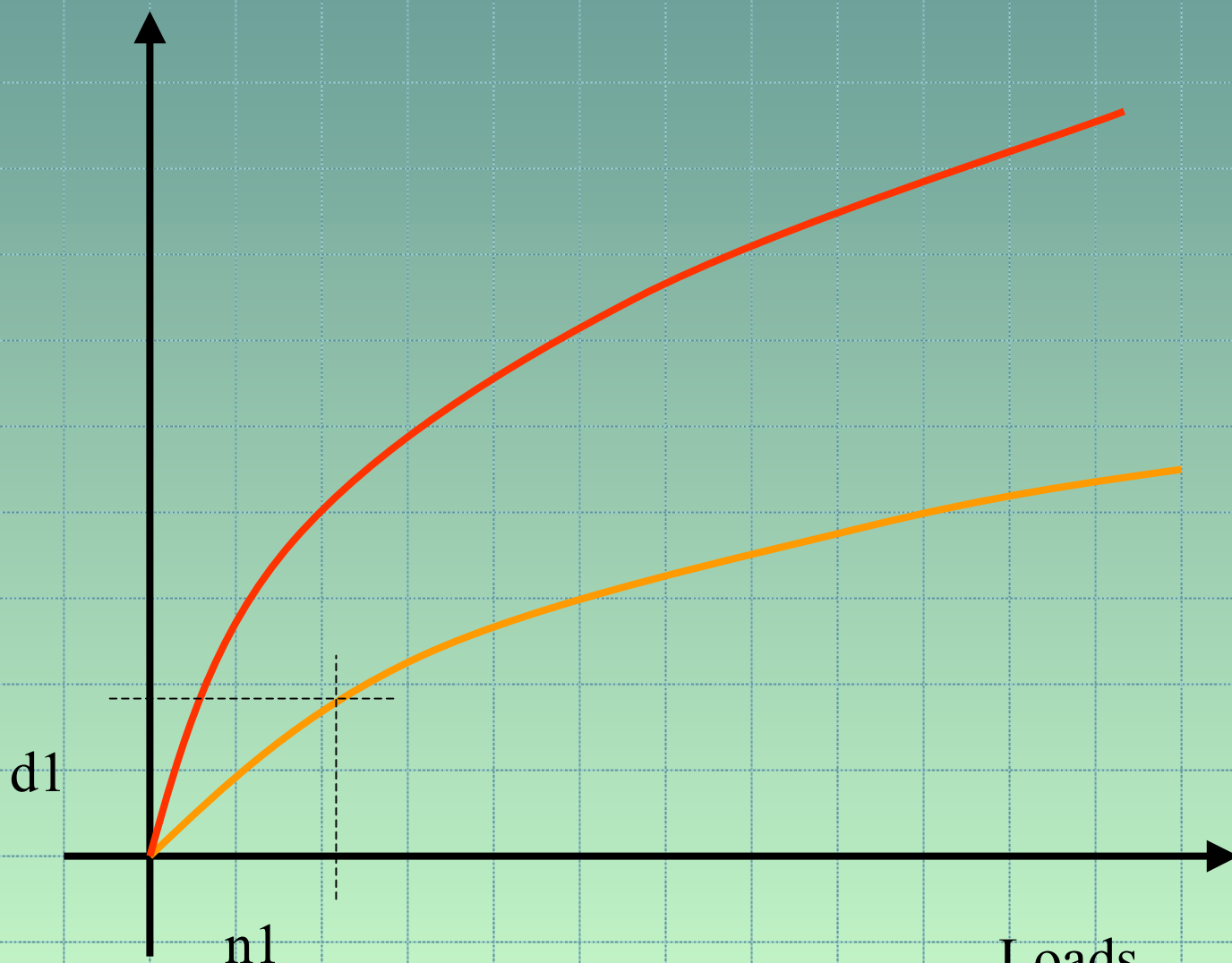
13/05/2003

Performance

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Damage

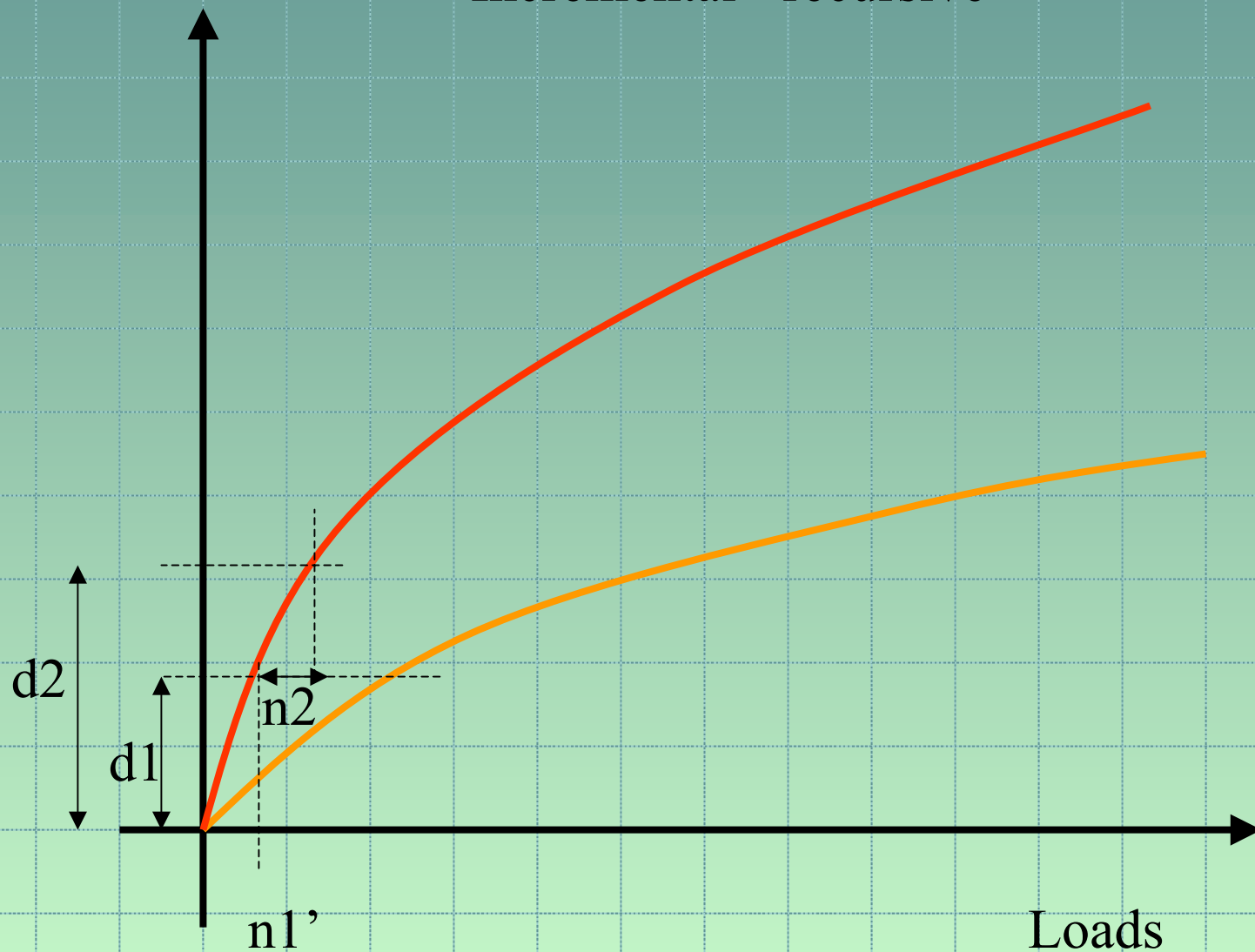


Loads

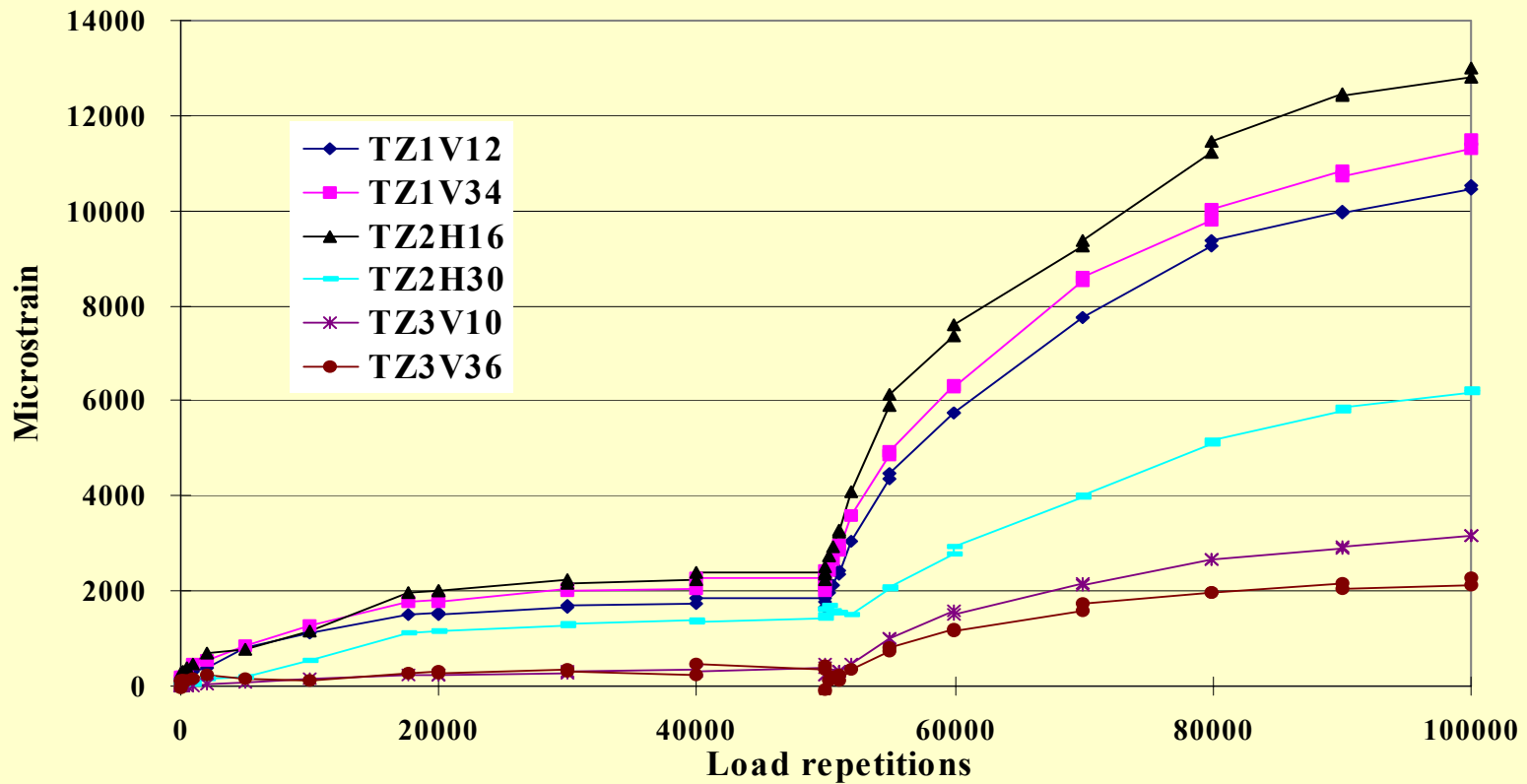


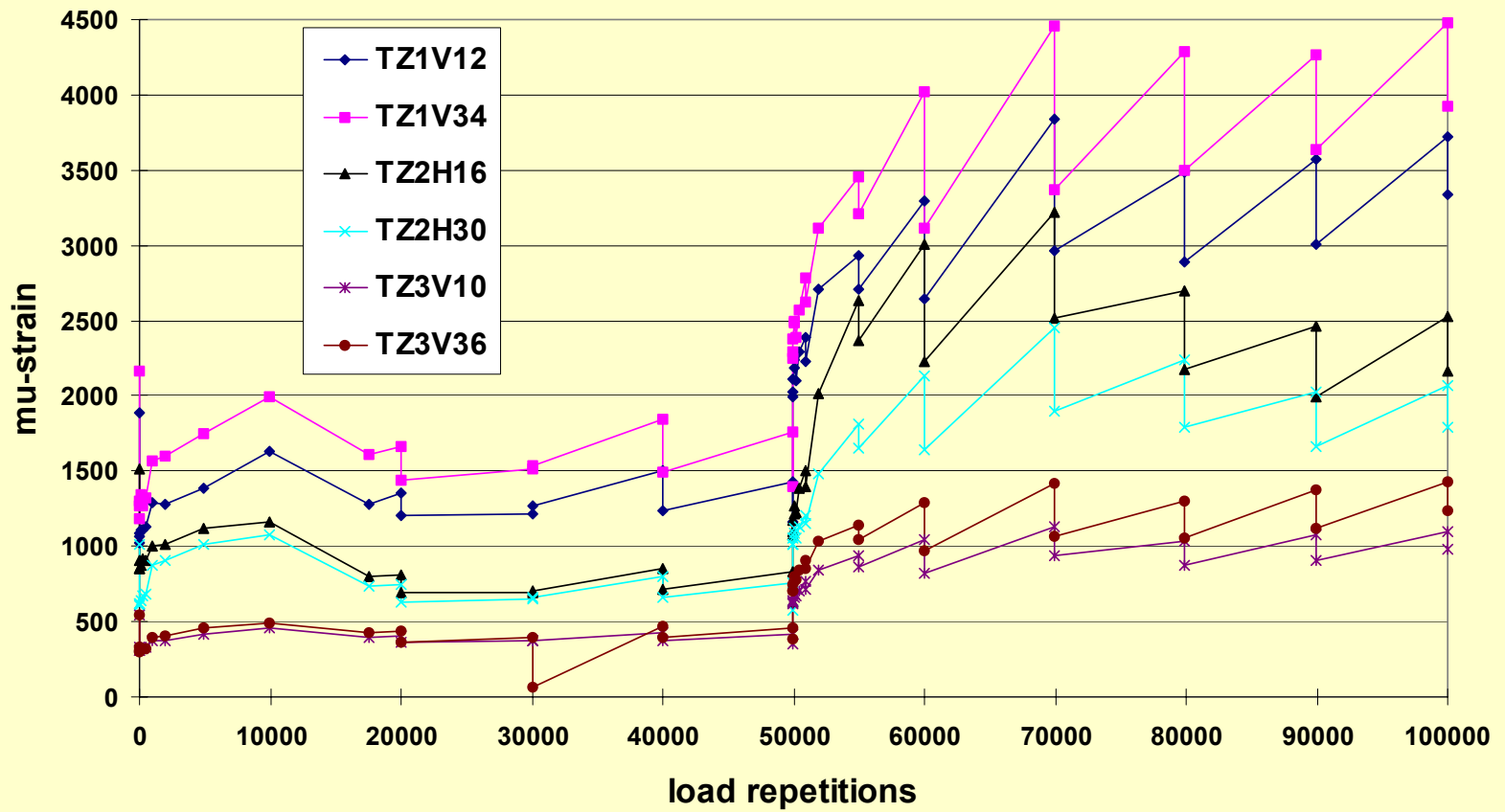
Damage

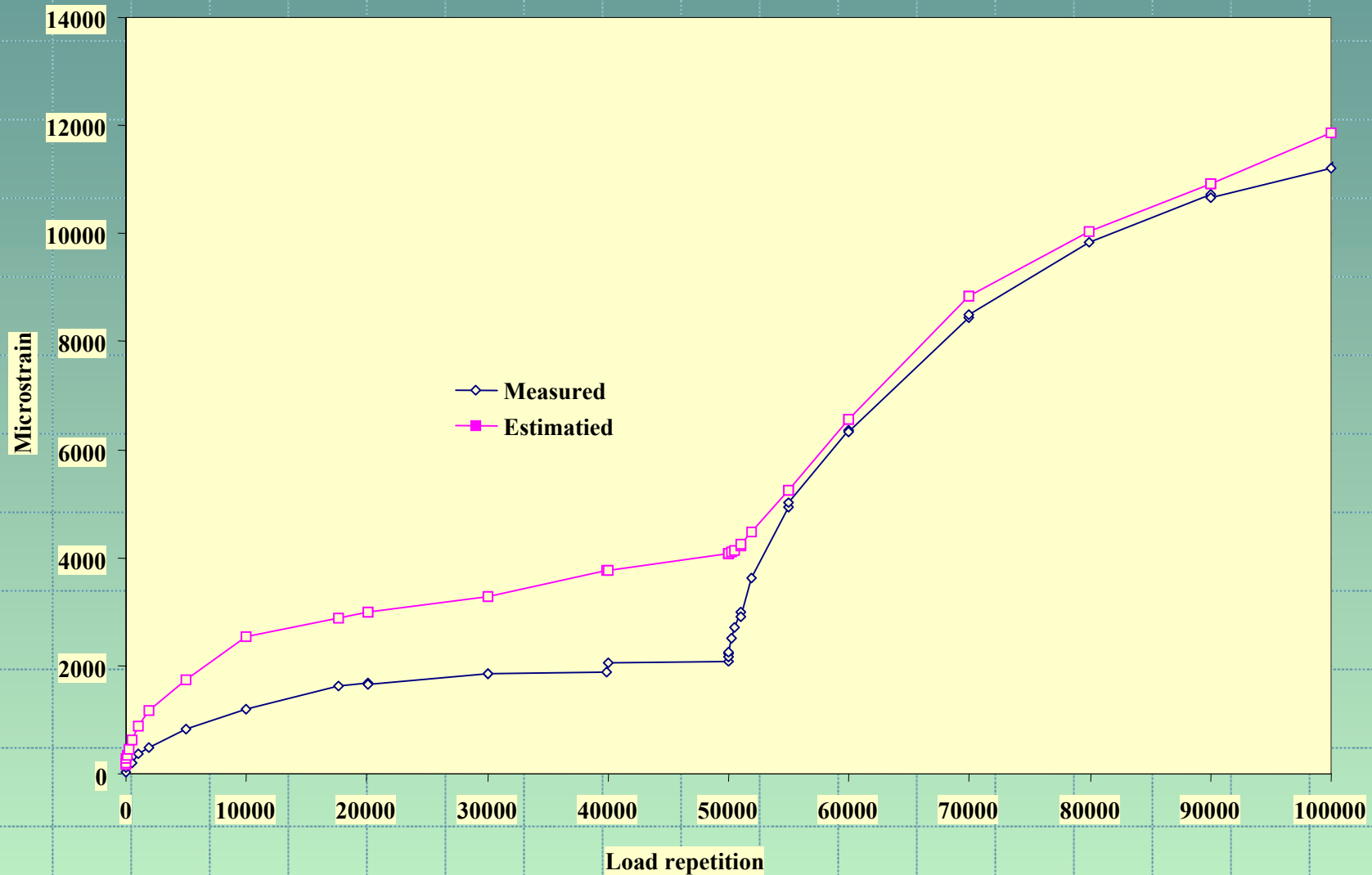
Incremental - recursive



Loads



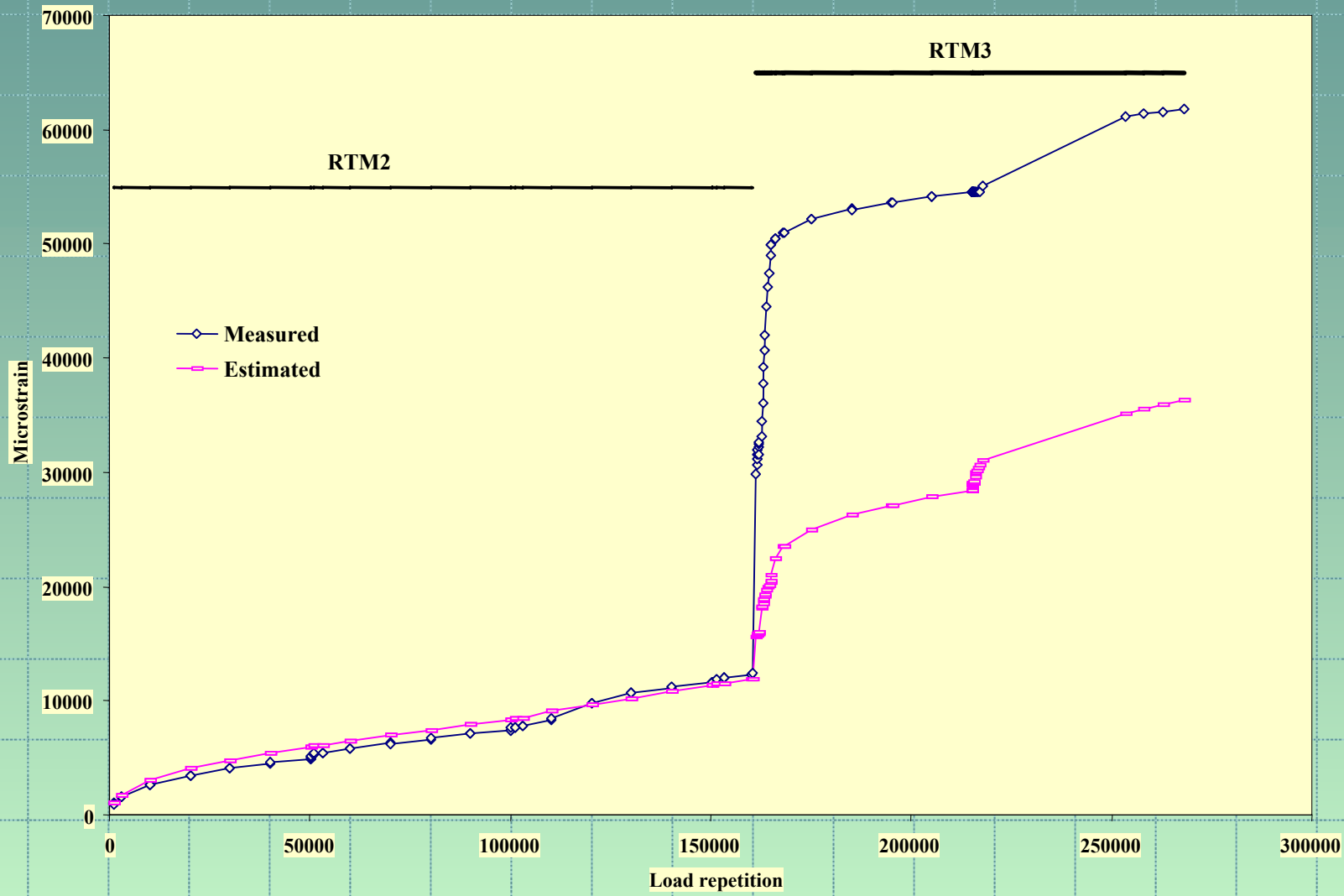






$$\mu\varepsilon_{zp} = 6880 \mu\text{strain} \times MN^{1/3} \times \left(\frac{\mu\varepsilon_z}{1000 \mu\text{strain}} \right)^{4/3} \times \left(\frac{E}{50 \text{MPa}} \right)^{1/3}$$

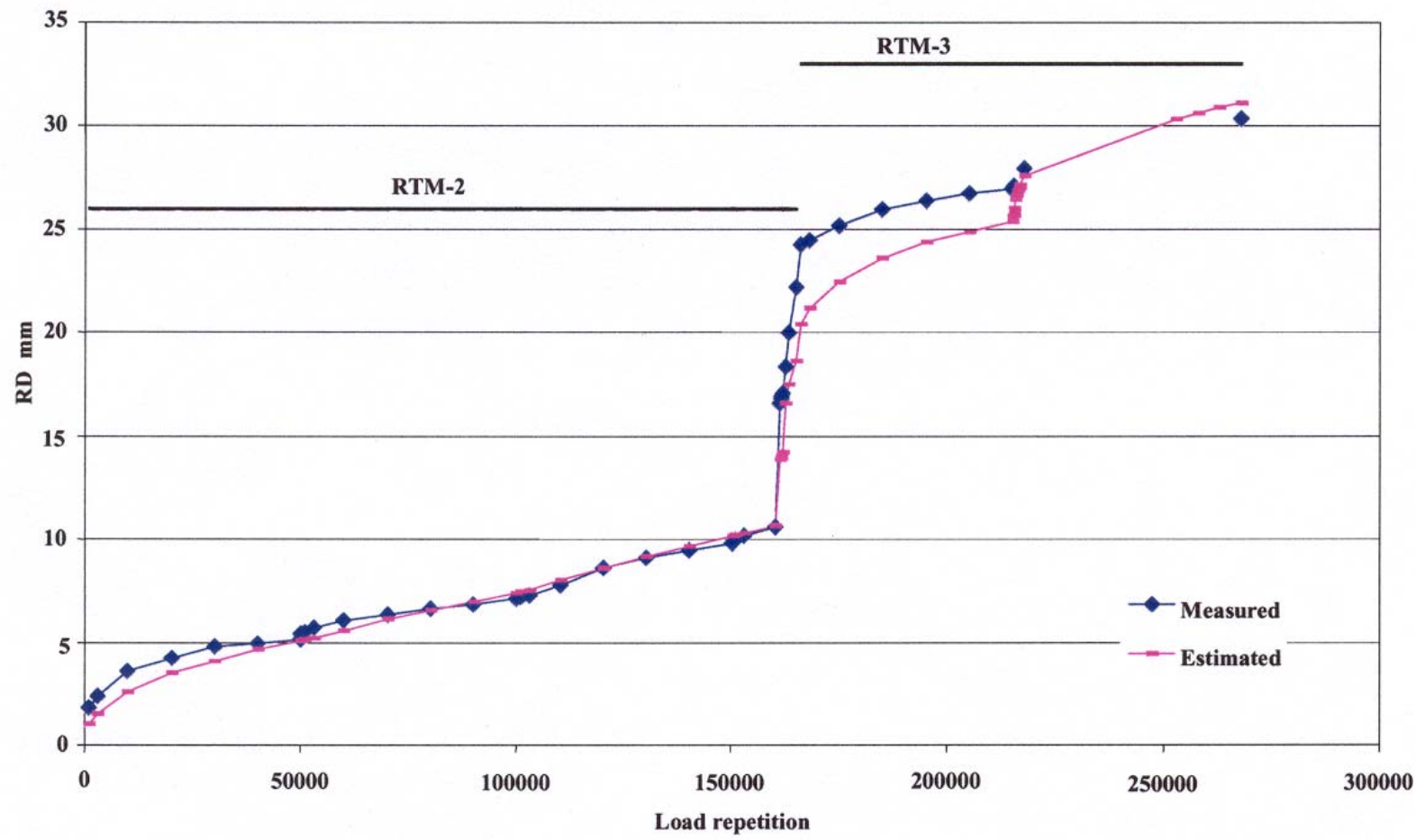
$$MN = \left(\frac{\mu\varepsilon_{zp}}{6880 \mu\text{strain}} \right)^3 \times \left(\frac{\mu\varepsilon_z}{1000 \mu\text{strain}} \right)^{-4} \times \left(\frac{E}{50 \text{MPa}} \right)^{-1}$$





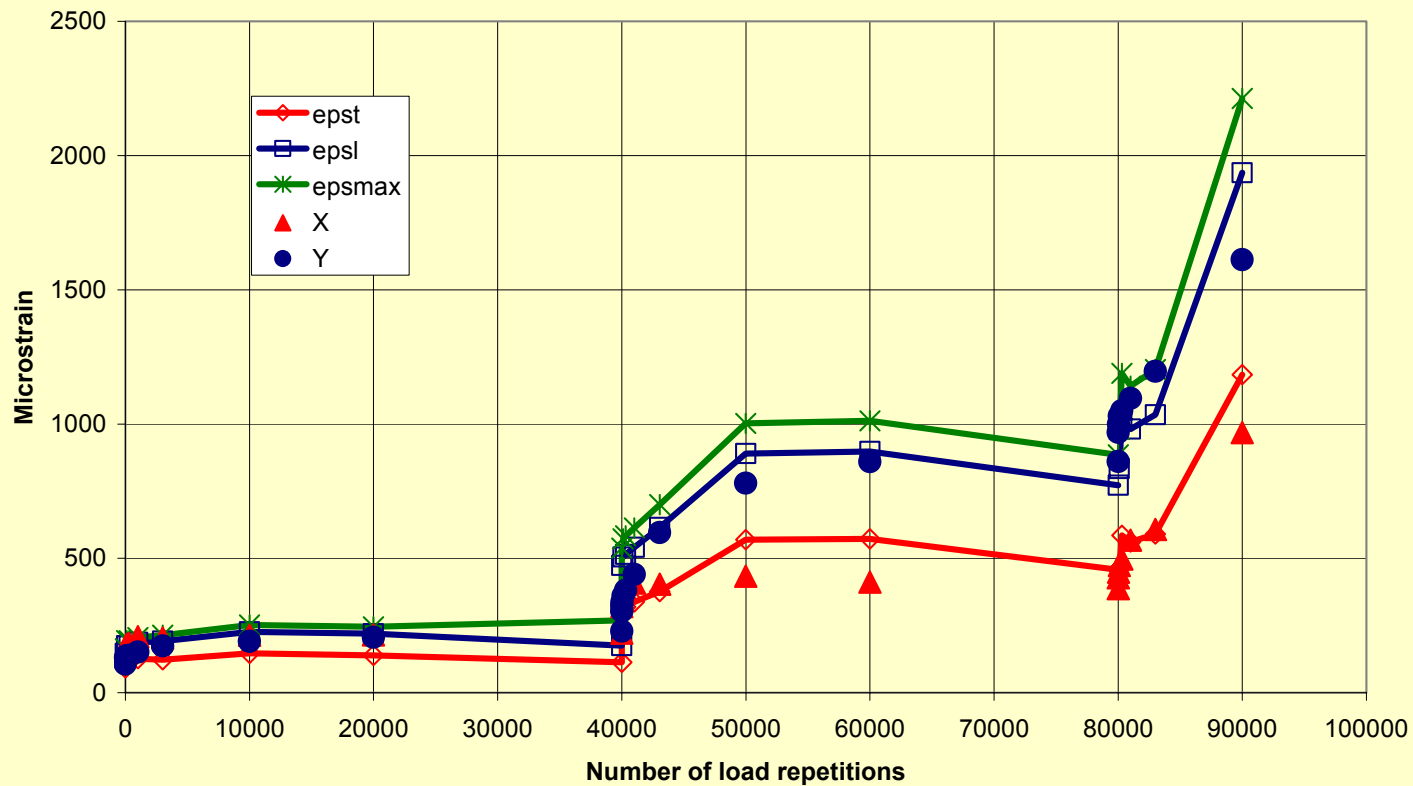
$$RD = 4.4mm \times MN^{1/3} \times \left(\frac{\mu\varepsilon_z}{1000 \mustrain} \right)^{4/3} \times \left(\frac{E}{50MPa} \right)^{1/3}$$

$$MN = \left(\frac{RD}{4.4mm} \right)^3 \times \left(\frac{\mu\varepsilon_z}{1000 \mustrain} \right)^{-4} \times \left(\frac{E}{50MPa} \right)^{-1}$$



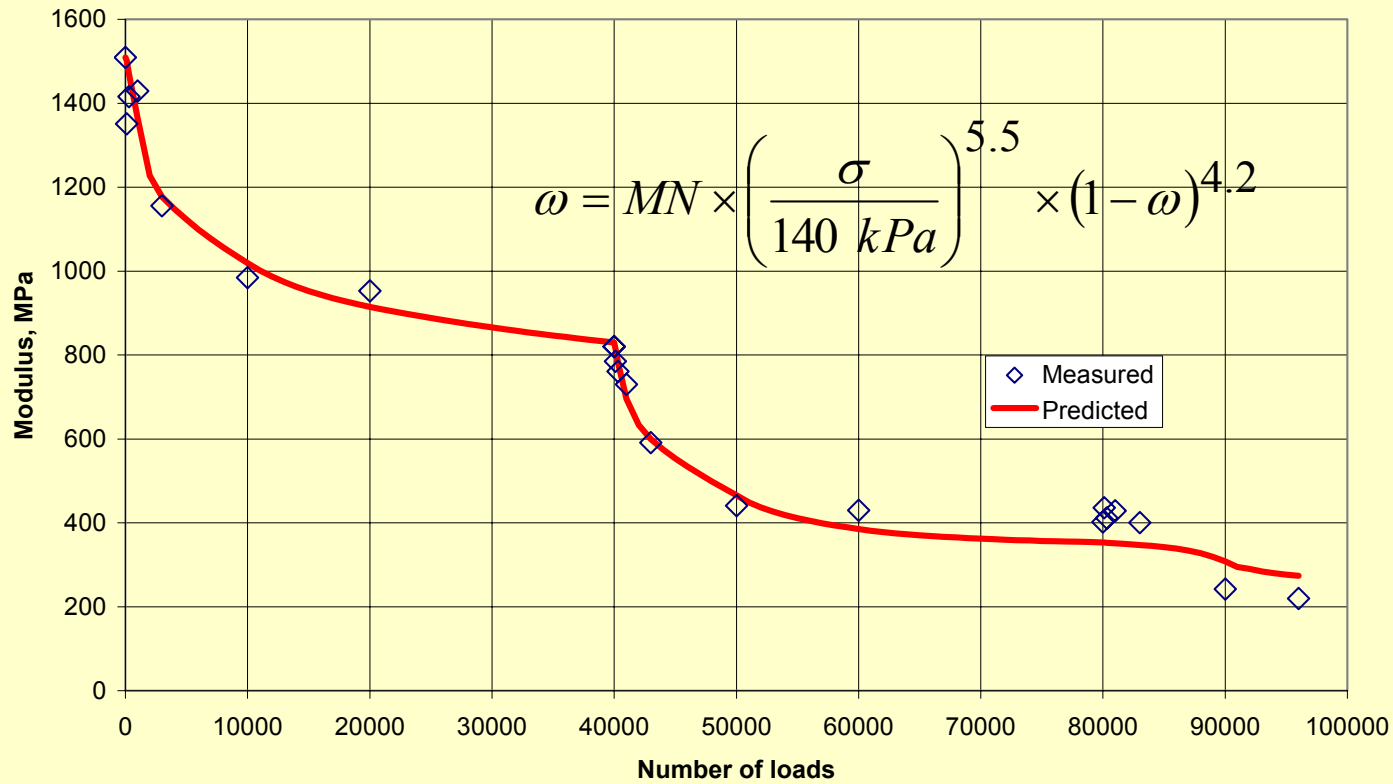


Measured and calculated strains





Measured and predicted modulus, zig





Measured and predicted modulus, eps

