KENTRACK

Version 2.0.1

Railway Trackbed Structural Design Software

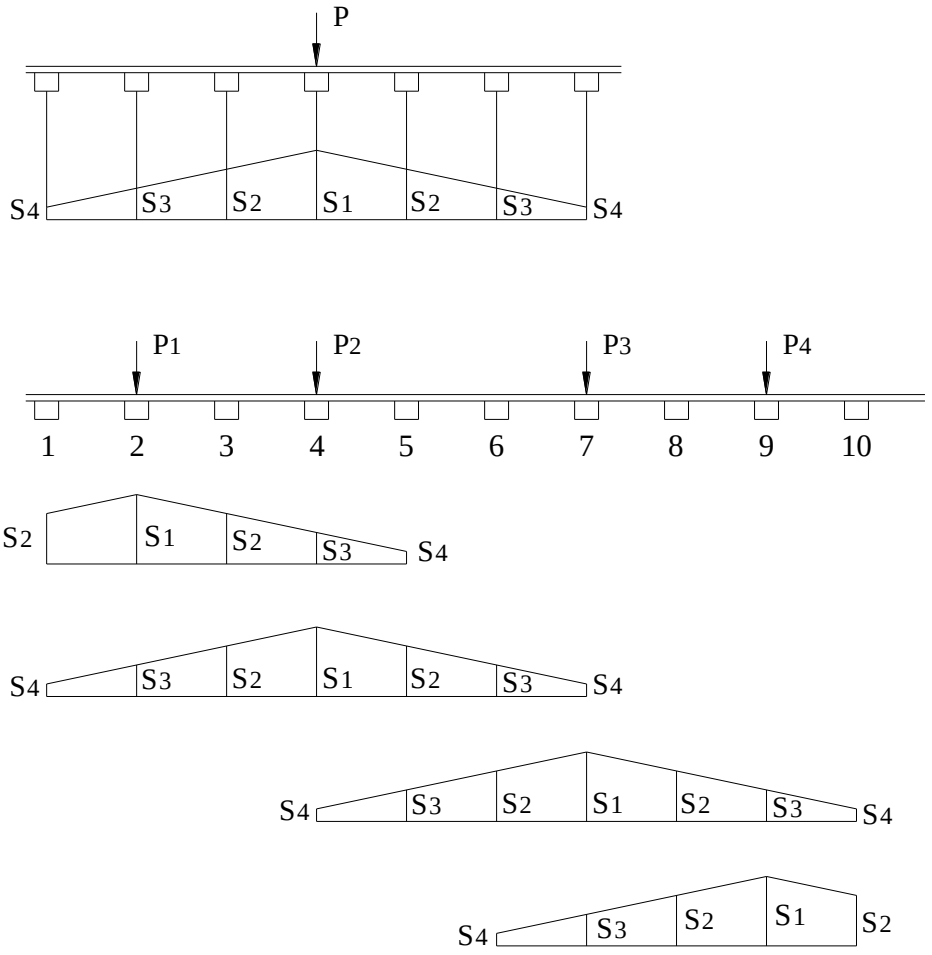
Background

- KENTRACK
  - Developed specifically to analyze HMA trackbeds
  - Has the versatility to analyze all-granular trackbeds
  - Initially a DOS based program
  - Upgraded to a windows based platform with a Graphic User Interface

Theory behind KENTRACK

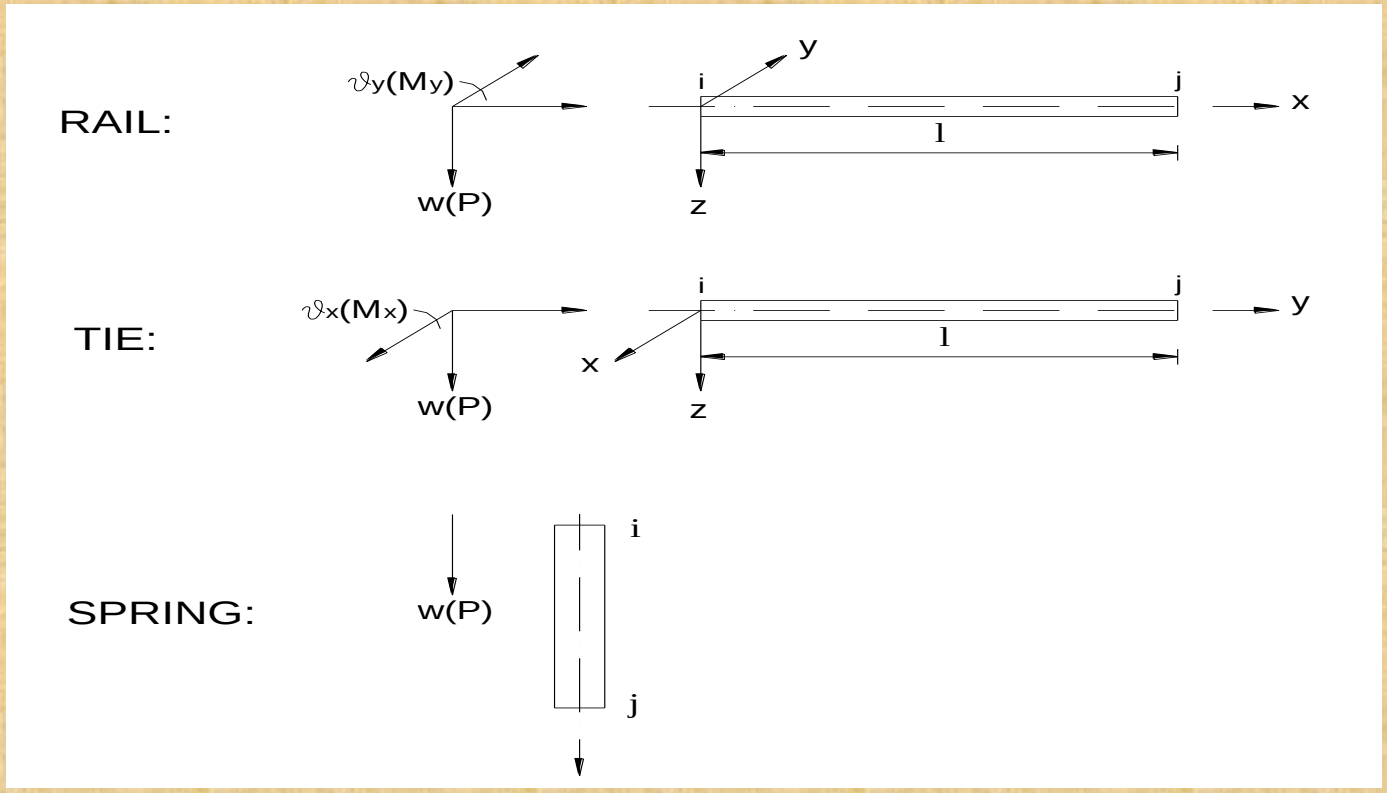
- Superposition of Loads

$$S_1^{'} = S_2 \frac{P_1}{P} + S_4 \frac{P_2}{P}$$



Theory behind KENTRACK

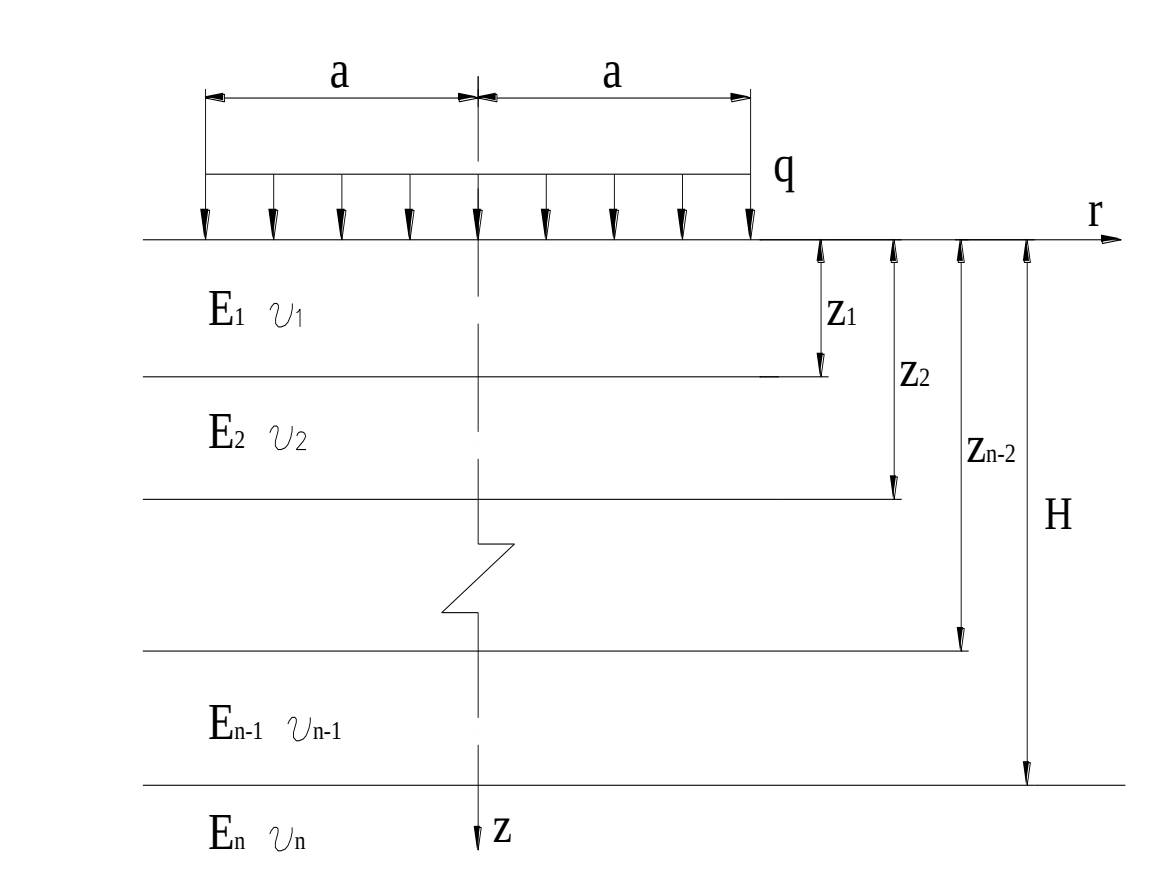
- Finite Element Method



- To calculate stresses and strains in rail and tie

Theory behind KENTRACK

- Multilayered System



- To calculate stresses and strains in the layers

Theory behind KENTRACK

- Material Properties
  - HMA trackbed is comprised of ballast, HMA and subgrade
  - All-granular trackbed is comprised of ballast, subballast and subgrade
  - Different equations are used to describe the material properties

Theory behind KENTRACK

- Ballast
  - In a new trackbed it behaves non-linearly
  - In an aged trackbed it behaves linearly

$$E = K_1 \theta^{K_2}$$

$$\theta = \sigma_1 + \sigma_2 + \sigma_3 + \gamma z(1 + 2K_0)$$

- Subgrade
  - Linearly elastic material

Theory behind KENTRACK

- Hot Mix Asphalt (HMA)
  Visco-elastic material

The dynamic modulus of HMA depends on

- Temperature
- Aggregate passing No. 200 sieve in %
- Volume of bitumen %
- Volume of air voids %
- Asphalt viscosity
- Load frequency

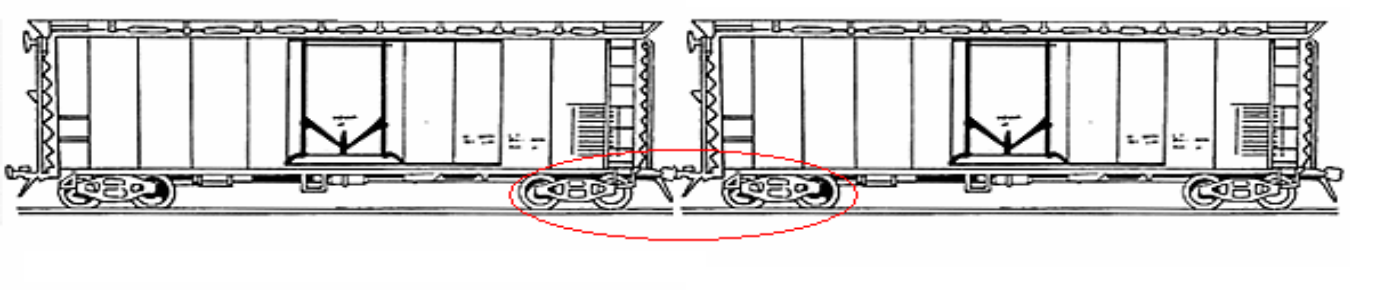
Theory behind KENTRACK

- Damage Analysis
  - Based on minor linear damage analysis criteria
  - Performed by periods (seasons, months)

$$L = \frac{1}{\sum_{i=1}^{n} \frac{N_p}{N_a \text{ or } N_d}}$$

Theory behind KENTRACK

- Predicted number of repetitions



Wheel Load	= 36000 lb/wheel
For one car the total weight	= 36000 lb/wheel x 8 = 286,000 lb/rep / 2000 = 143 ton/rep
The number of repetitions assumed per year	= 200,000 rep/yr
The traffic per year	= 200,000 rep/yr x 143 ton/rep = 28,600,000 GT/yr / 1 x 10^6 = 28.6 MGT/yr

Theory behind KENTRACK

- HMA Damage Analysis
  - Fatigue cracking controls failure
  - Fatigue cracking is governed by the tensile strain at the bottom of HMA
  - Based on highway experience
  - Number of allowable repetitions (N_a) before failure

$$N_a = 0.0795\,\varepsilon_t^{-3.291} E_a^{-0.853}$$

Theory behind KENTRACK

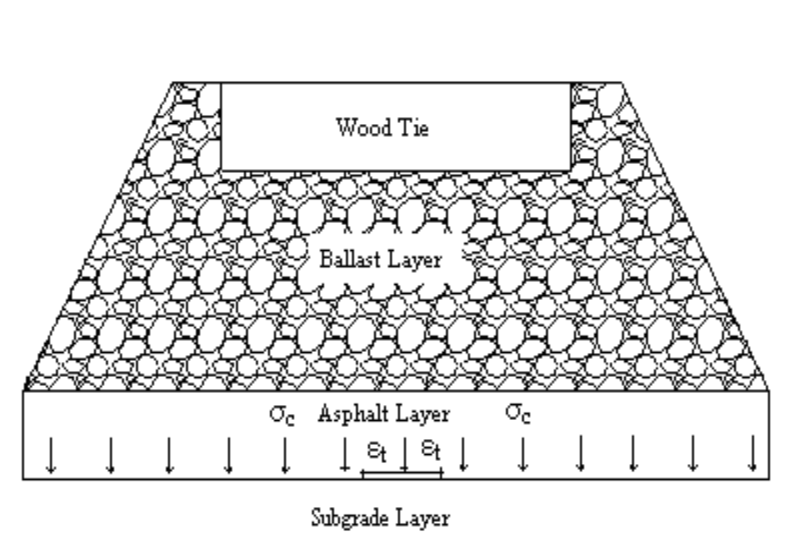
- Subgrade Damage Analysis
  - Excessive permanent deformation controls failure
  - Deformation is governed by the vertical compressive stresss on top of subgrade
  - Based on highway experience
  - Number of allowable repetitions (N_d) before failure

$$N_d = 4.837 \times 10^{-5} \sigma_c^{-3.734} E_s^{+3.583}$$

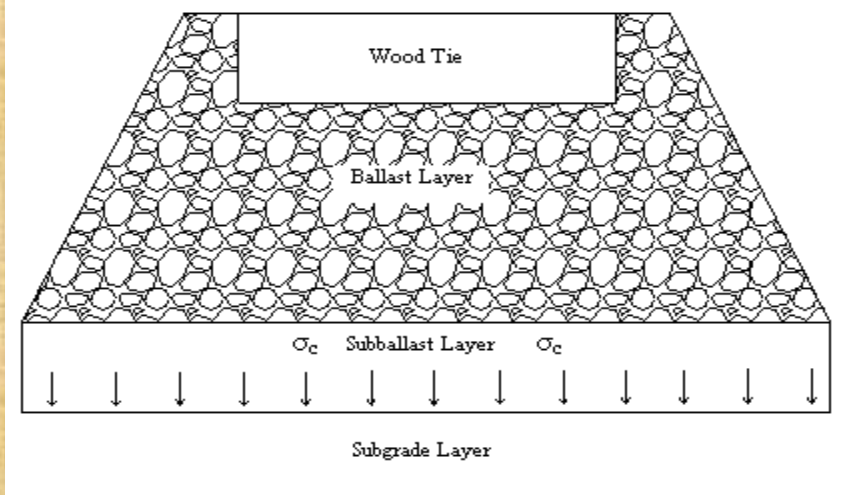
Theory behind KENTRACK

Stresses and Strains

Asphalt Trackbed



All-Granular Trackbed



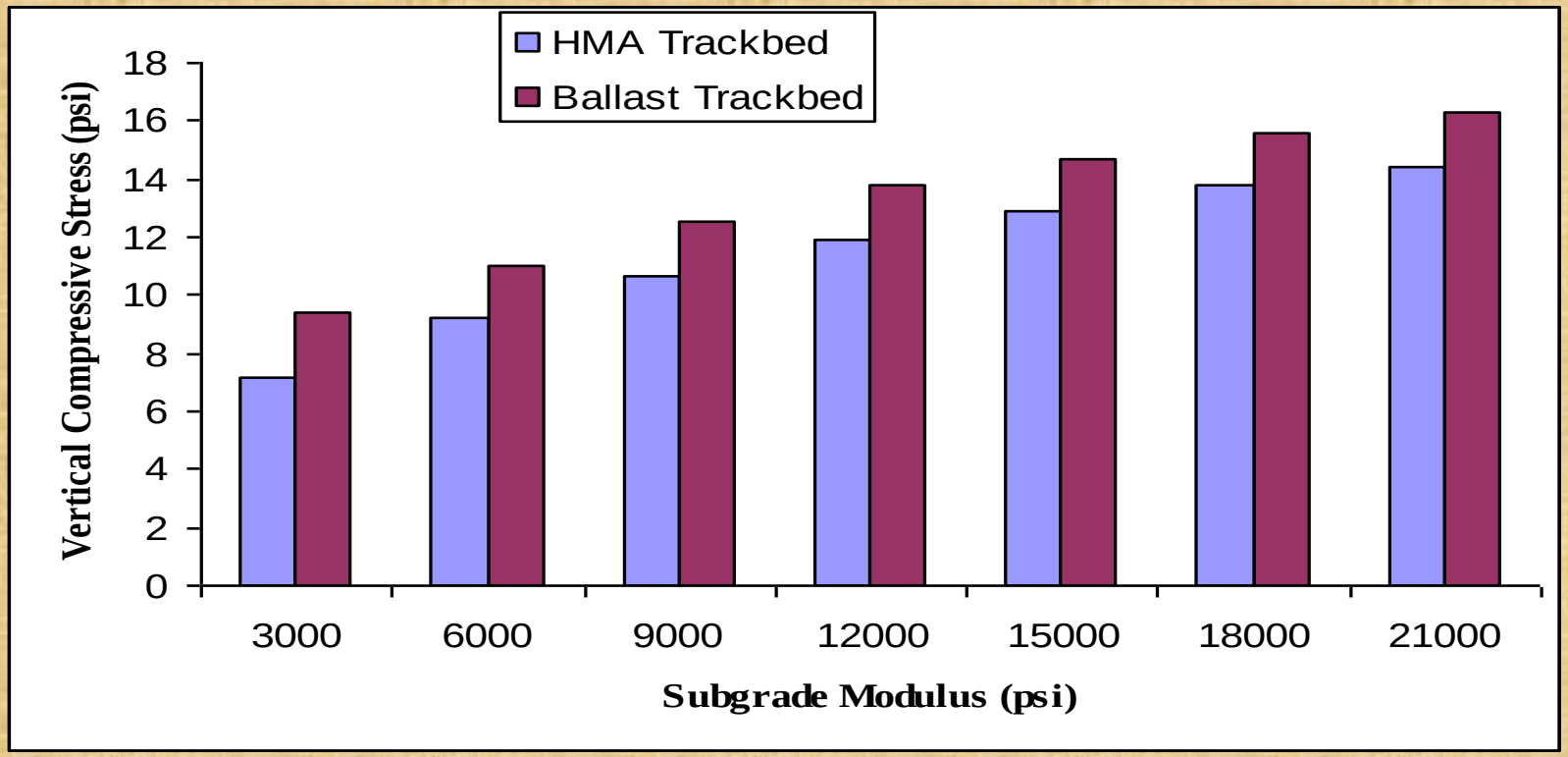
Methodology

- Critical outputs for the two sections

Critical Outputs		
Variable	Standard HMA trackbed	Standard Ballast Trackbed
Subgrade Vertical Compressive Stress (psi)	11.9	13.8
HMA Tensile Strain (in/in)	0.000183	N/A
Service life of Subgrade (yrs)	15.2	5.6
Service life of HMA (yrs)	19.8	N/A

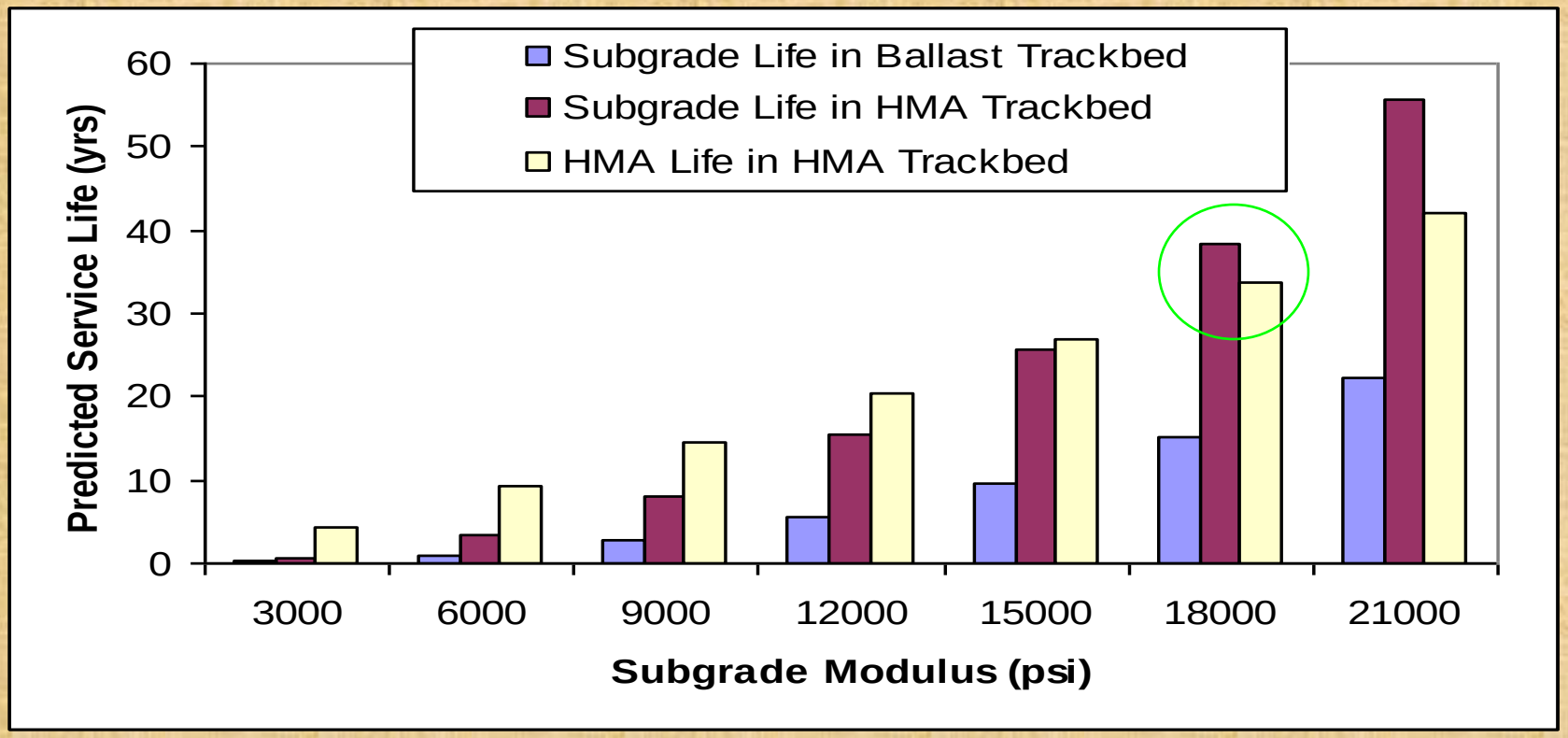
Effect of Subgrade Modulus on σ_c

Axle Load – 36 tons



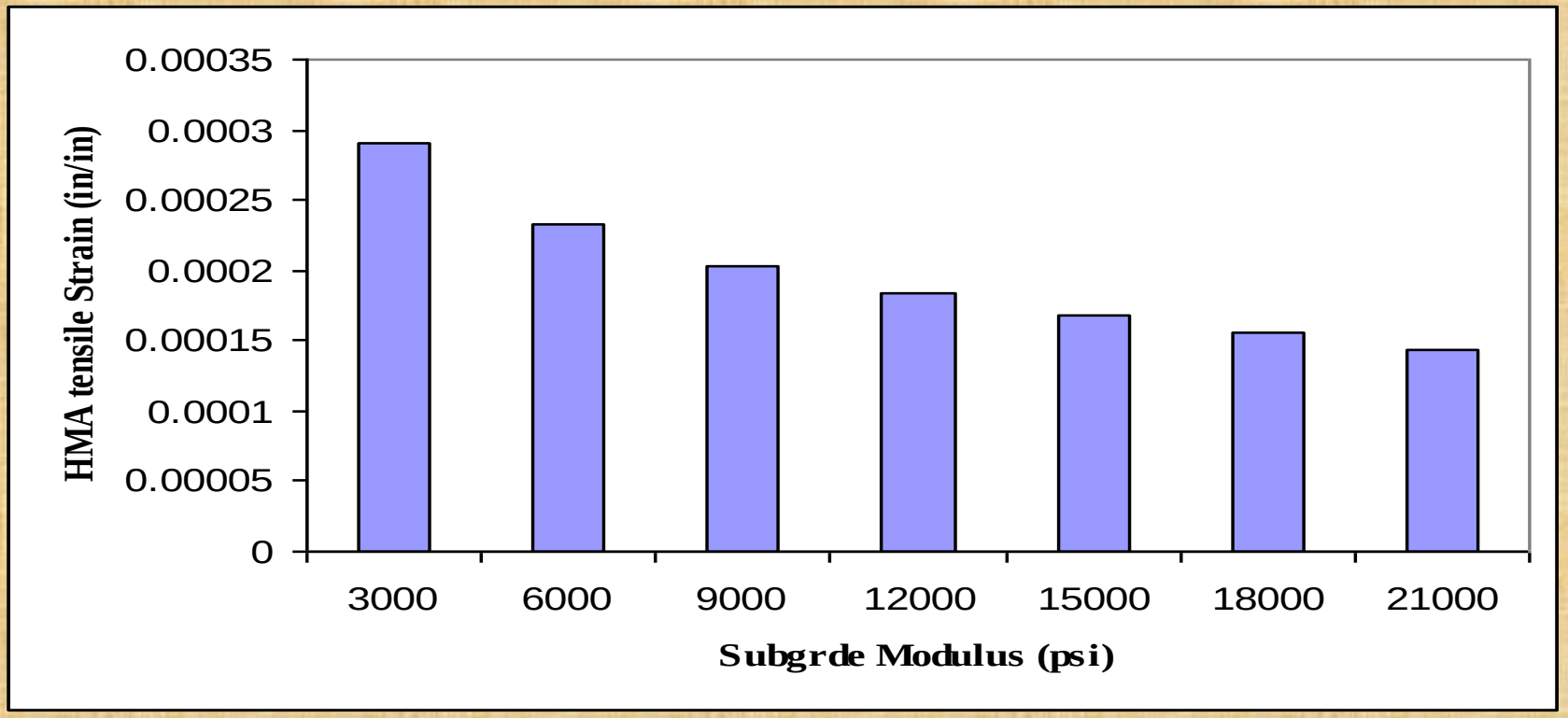
Effect of Subgrade Modulus on L

Axle load - 36 tons



Effect of Subgrade Modulus on ε_t

Axle load – 36 tons



Predictive Values Versus In-track Data

Comparison of the KENTRACK Predictive values (KPV) Versus In-Track Data (ITD) for the CSX Mainline at Conway, Kentucky			
Thickness Ballast-HMA inches	Vertical Compressive Stress on **Ballast** KPV/TTD psi	Vertical Compressive Stress on **HMA** KPV/TTD psi	Vertical Compressive Stress on **Subgrade** KPV/TTD psi
10 / 5	47.9 / -	21.0 / 16.0	13.6 / -
10 / 8	48.7 / -	22.0 / 15.0	11.7 / -

Comparison of the KENTRACK Predictive values (KPV) Versus In-Track Data (ITD) at TTCI in Pueblo, Colorado			
Thickness Ballast-HMA inches	Vertical Compressive Stress on **Ballast** KPV/TTD psi	Vertical Compressive Stress on **HMA** KPV/TTD psi	Vertical Compressive Stress on **Subgrade** KPV/TTD psi
12 / 4	43.5 / -	11.7 / 14.9	8.3 / 8.0
8 / 8	47.0 / -	21.9 / 114.9	8.2 / 7.7

Summary

- KENTRACK is a versatile program that can be used to analyze HMA and all-granular trackbeds
- HMA trackbeds improve the service life and perform better than all-granular trackbeds
- Damage analysis values are conservative
- Subgrade modulus is a very important factor in trackbed design