Introduction to Pavement Engineering
Homework #5: Material Characterization

Problem 1:

A conventional triaxial compression test involves increasing axial stress, while keeping lateral (confining) stress constant. The table below shows the results of resilient modulus tests (repeated load triaxial tests) on the granular material. The distance between the LVDT clamps is 4 inches. The average recoverable deformations measured by the two LVDTs after 200 repetitions of each deviator stress are shown in the Table.

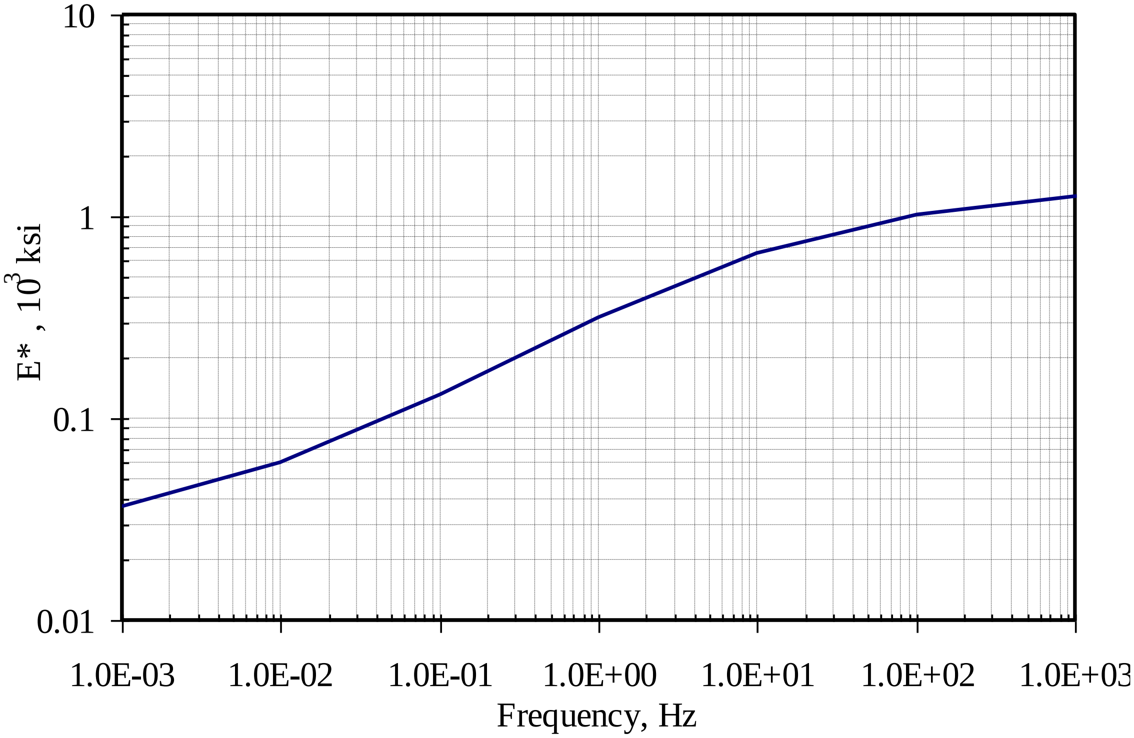
a) Sketch the total axial stress and the axial strain as a function of time.
b) Calculate the resilient (elastic, recoverable) axial strain.
c) Calculate the resilient modulus, M_R.
d) Calculate the stress invariant, θ
e) Develop an equation relating the resilient modulus to the first stress invariant, $M_R = k_1(\theta)^{k_2}$.

Table 1: Resilient Modulus Test Results

σ_3 (psi)	σ_d (psi)	δ_r (0.001 in.)	ε_r (x 10^{-3})	M_R (x10^3 psi)	θ (psi)
20	1	0.205			
	2	0.446			
	5	1.005			
	10	2.029			
	15	3.119			
	20	3.998			
15	1	0.260			
	2	0.512			
	5	1.300			
	10	2.500			
	15	3.636			
	20	4.572			
10	1	0.324			
	2	0.672			
	5	1.740			
	10	3.636			
	15	3.872			
5	1	0.508			
	2	0.988			
	5	2.224			
	10	3.884			
	15	5.768			
1	1	0.636			
	2	0.880			
	5	2.704			
	7.5	3.260			
	10	4.444			

Problem 2:

The following chart shows the dynamic modulus (|E*|) of a HMA mixture at 70°F.



2.1) For an 8 inches HMA layer, determine the time of loading and the dynamic modulus under a vehicle traveling at 30 mph and 1 mph, and at depths of 1, 3, 5, and 7 inches below the pavement surface (use a sinusoidal pulse load).

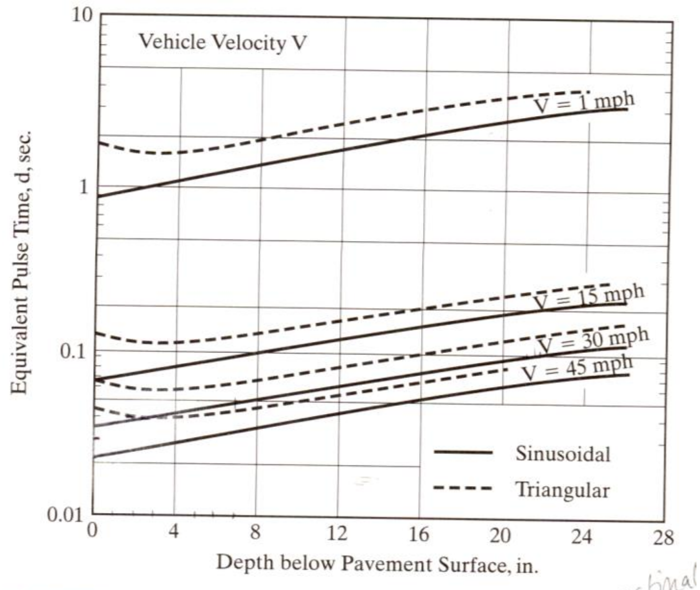
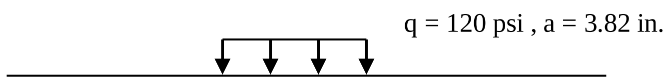


FIGURE 7.3

Vertical stress pulse time under haversine or triangular loading (1 in. = 25.4 mm. 1 mph = 1.6 km/h). (After Barksdale (1971).)

2.2) Calculate the number of load repetitions N_f to cause fatigue cracking at the bottom of the HMA layer under a vehicle traveling at 30 mph and 1 mph. Use the average |E*| from (2.1) for the HMA layer. (Strain at the bottom of the HMA layer was 0.00009541 and 0.0001892 for 30mph and 1 mph, respectively)

Asphalt Institute model for 20% of area cracked: $$N_f = 0.0796 \times \left(\frac{1}{\varepsilon_t}\right)^{3.291} \left(\frac{1}{E_1}\right)^{0.854}$$



HMA, 8”	| E*|	ν = 0.35
CAB, 10”	M_R = 15,000 psi	ν = 0.40
SG	M_R = 6,000 psi	ν = 0.45