Chapter 2

2.1

Truck shown in Figure 2.9(a).

Use Table 2-8 for single axle and penalize load by 10% for single tires:
Steering: 63.4 kN x 1.1 = 69.7 4 kN therefore ESAL = 0.575

Use Table 2.9 for tandem axles:
Drive axle: 128.2 kN therefore ESAL = 0.557
Trailer axle: 148.3 kN therefore ESAL = 1.009
Total for vehicle ESAL = 2.14

Truck show in Figure 2.9(b).

Use Table 2-8 for single axle and penalize load by 10% for single tires:
Steering: 53.2 kN x 1.1 = 58.5 4 kN therefore ESAL = 0.285

Use Table 2.9 for tandem axles:
Drive axle: 92.5 kN therefore ESAL = 0.261
Trailer axle: 52 kN therefore ESAL = 0.139
2nd Trailer axle: 50.2 kN therefore ESAL = 0.012
Total for vehicle ESAL = 0.697 rounded to 0.7

2.2

Compute the dynamic load Coefficient of Variation (*CV*) using Equ. 2.2 and the constants given on table 2.3.

Air-spring suspension:

$$CV = 70^{0.346} 2.2^{0.798} = 8.16\%$$

Rubber-spring suspension:

$$CV = 70^{0.456} 2.20.728 = 12.32\%$$

Compute standard dynamic load deviations:

Tractor: 0.0816 x 75 = 6.12 kN

Trailer: 0.1232 x 70 = 8.62 kN

Assuming that the dynamic load is normally distributed, the following ranges are obtained for 90% confidence:

Tractor: 75 ± 1.65 x 6.12 = [85.1, 64.9] kN

Trailer: 70 ± 1.65 x 8.62 = [74.2, 55.8] kN

Where 1.65 is the standard normal deviate for 90% confidence.

2.3

The maximum dynamic load range tolerated for the tandem tractor axle is 20/1.65 = 12.1 kN, or 6.06 kN for each individual axle. This reflects a *CV* of 6.06/75 = 8.08%

Similarly, the maximum dynamic load range tolerated for the tandem trailer axle is 20/1.65 = 12.1 kN, or 6.06 kN for each individual axle. This reflects a *CV* of 6.06/70 = 8.66%.

Solve Equ. 2.2 for speed:

Tractor air-spring:

$$8.08 = V^{0.346} 2.2^{0.798}$$

Trailer rubber-spring:

$$8.66 = V^{0.456} 2.2^{0.728}$$

Solution gives speeds of 68 km/h and 32.3 km/hr. The latter governs.

2.4

WIM error computations:

	WIM Pass 1	WIM Pass 2	WIM Pass 3	WIM Pass 4	WIM Pass 5
Test Vehicle 1					
steering	-16.78	11.76	-5.66	9.15	1.31
drive, axle 1	5.41	-14.10	7.26	-17.09	-30.34
drive, axle 2	-9.30	3.85	7.97	-20.05	7.44
trailer, axle 1	-13.92	-16.50	-4.59	-30.70	-3.87
trailer, axle 2	-15.44	-30.73	-35.32	2.60	-0.31
GVW	-9.40	-10.17	-5.45	-13.05	-5.51

Test Vehicle 2					
steering	-12.04	4.17	1.85	3.01	-0.93
drive, axle 1	-17.98	10.59	12.84	-22.47	-10.43
drive, axle 2	-21.99	-17.25	23.89	-12.97	-21.04
trailer, axle 1	-5.34	-7.07	0.58	-2.60	-2.60
trailer, axle 2	-7.41	-11.68	1.57	-8.83	-4.56
GVW	-12.72	-5.06	8.24	-9.38	-8.18

Four of 50 WIM measurements violate the ±30% rule for weighing individual axles (shaded cells), which represent a 92% < 95% conformity and hence, this system does not satisfy Type II WIM requirements. The average error in axle load measurements is -6.73% which suggests a calibration factor adjustment factor of 1.0722.

2.5:

Consider the vehicle shown in Figure 2.10. Single axle loads and tandem axle load limits are satisfied, since the single axle load 68 < 89 kN, and the tandem axle loads of 108 < 151 kN and 135 < 151 kN. The GVW is 311 < 356 kN.

Check whether this vehicle satisfies the bridge formula requirement given by Equ. 2.8, by testing first the tractor that has a wheel base of *L* = 4.8 m, and rides on *N* = 3 axles:

$$W = 2.224\left(\frac{0.3048\ 4.8\ \ 3}{3-1}+12\ 3+36\right) = 165\ \text{kN}$$

The weight of the tractor is 176 kN, which exceeds the maximum allowable calculated above. Hence, this vehicle is not legally loaded-no further bridge formula checks are needed.

Chapter 3

3.1:

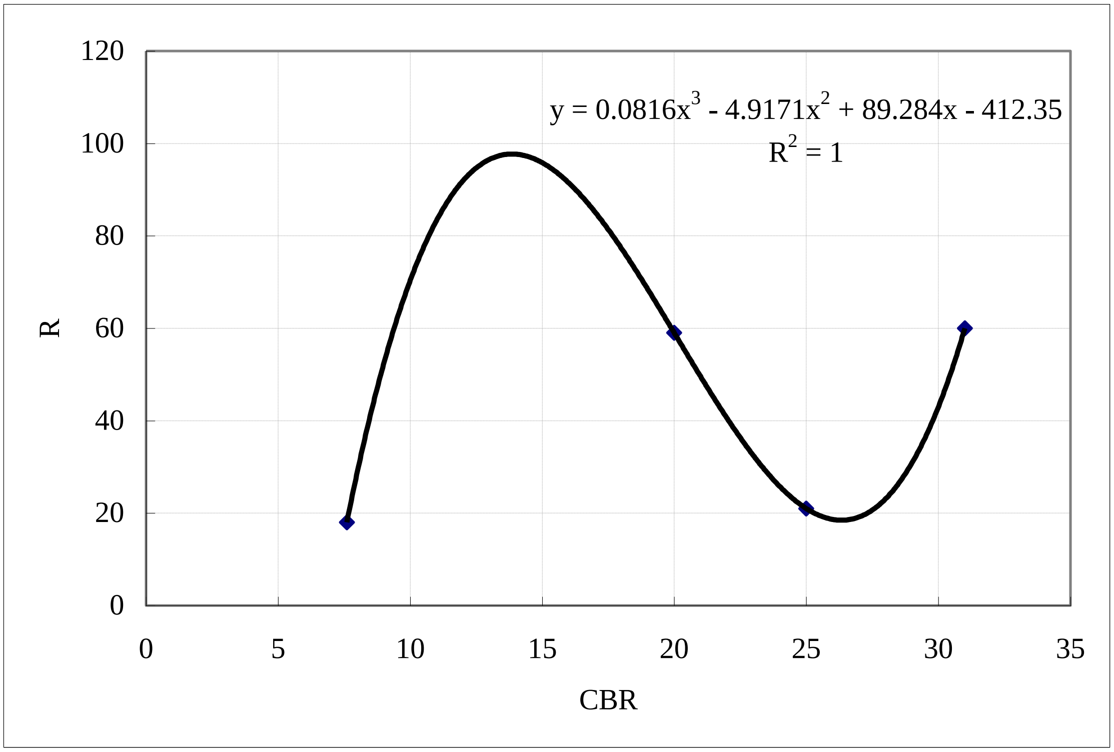
Provide a summary of the subgrade, subbase and the base properties that are needed as input to the proposed design guide from the NCHRP 1-37A design approach.

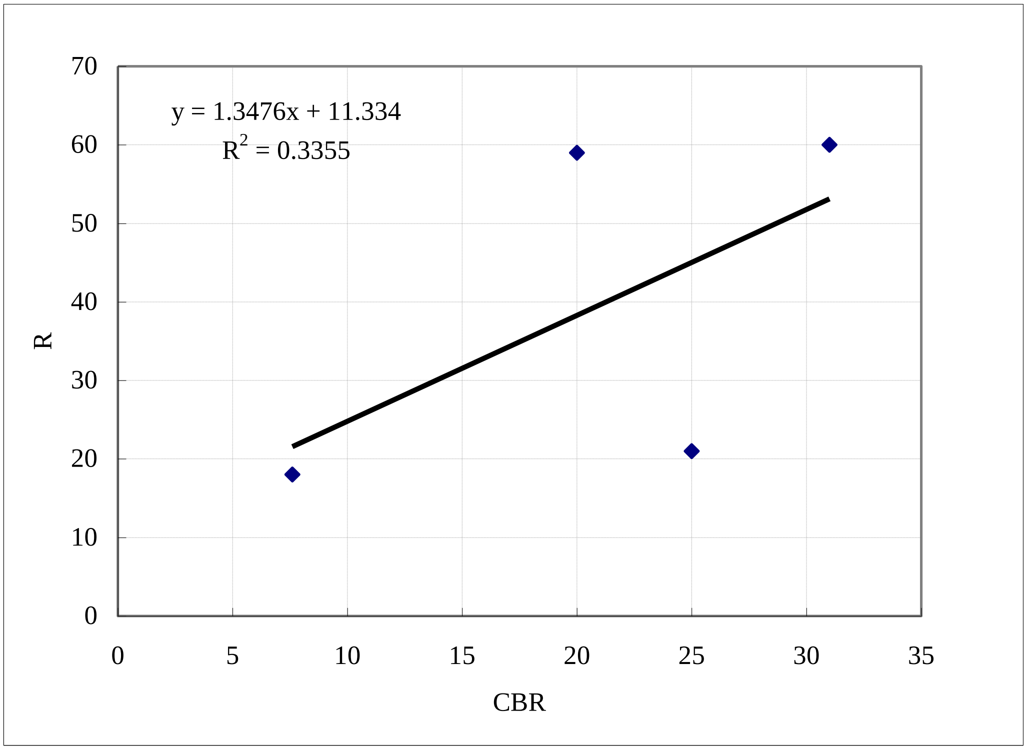
Materials inputs required for critical response computations
Seasonally adjusted resilient modulus (Enter κ_1, κ_2 and κ_3; or R-value; or CBR(%)).
Poisson's ratio (Default=0.35)
Unit weight (Maximum dry unit weight and Specific gravity of solids)
Coefficient of lateral pressure (κ_0 Default=0.5)
Gradation parameters and base erodibility (for rigid pavement design)
Plasticity index, gradation parameters, effective grain size, specific gravity, saturated hydraulic conductivity, optimum moisture contents, parameters to define the soil water characteristic curve

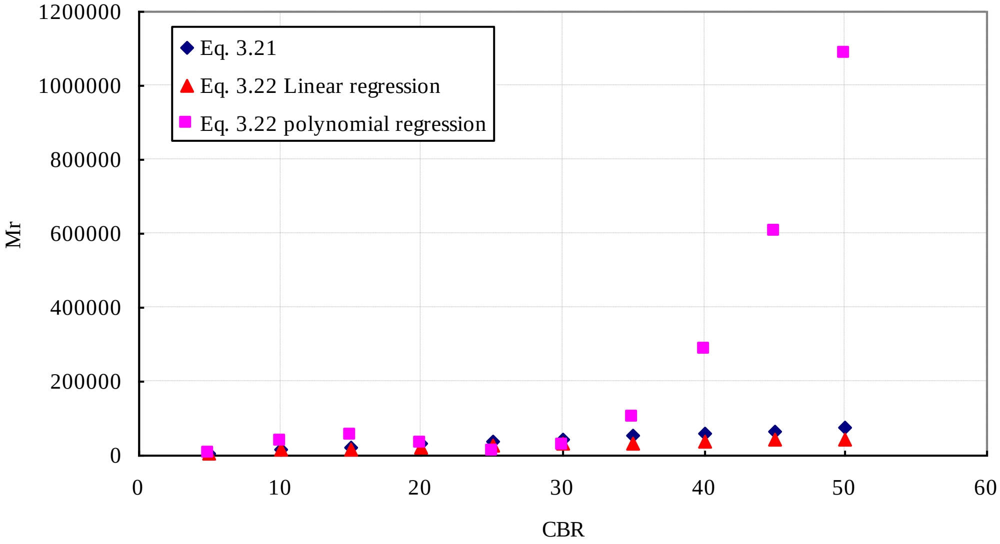
3.2 Plot the relationships between resilient modulus and CBR given in Equations 3.21 and 3.22 for a range of CBR values from 5 to 50. Comment on the predictions of these two equations.

Only Eq. 3.21 deals with the relationship between Mr and CBR; while Eq. 3.22 is the equation about R-Value. Hence, I select Eq. 3.23, which is a relationship between Mr and R-Value, and use Table 3.9 to regress the relationship between CBR and R-Value. After obtaining R-value, Mr can be calculated from Eq. 3.23 with R-value.

The figure shows that Mr predicted by Eq. 3.21 and 3.23 are close, when CBR less than 30. After that, the difference between these two equation increases with increasing CBR.







3.3 Discuss the benefits of subgrade and base stabilization using lime.

The benefits of using lime to stabilize subgrade and base are:

1. The stabilized subgrade and base have a smaller volume, higher strength, better resilient properties and better workability;
2. The stabilized subgrade and base have greater capability to resist fatigue and fracture, and lower sensitivity to changes in moisture content.