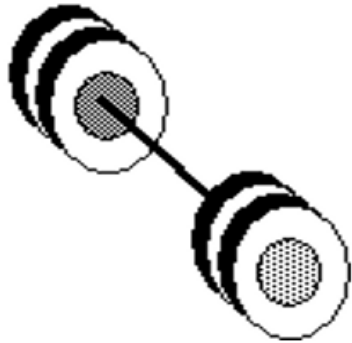
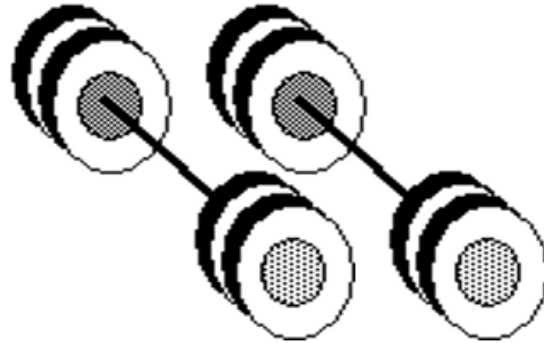


Traffic and Axle Loads

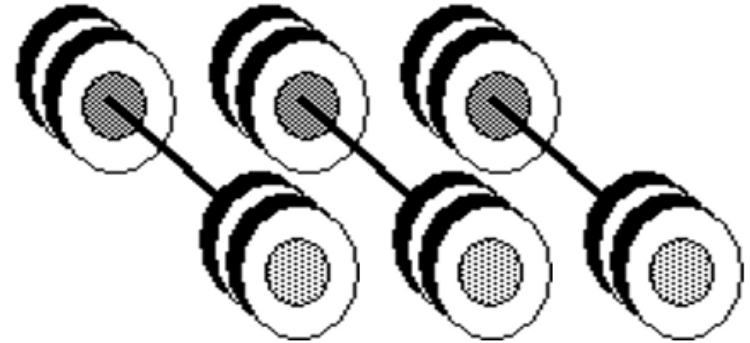
Typical Axle Combinations



Single Axle

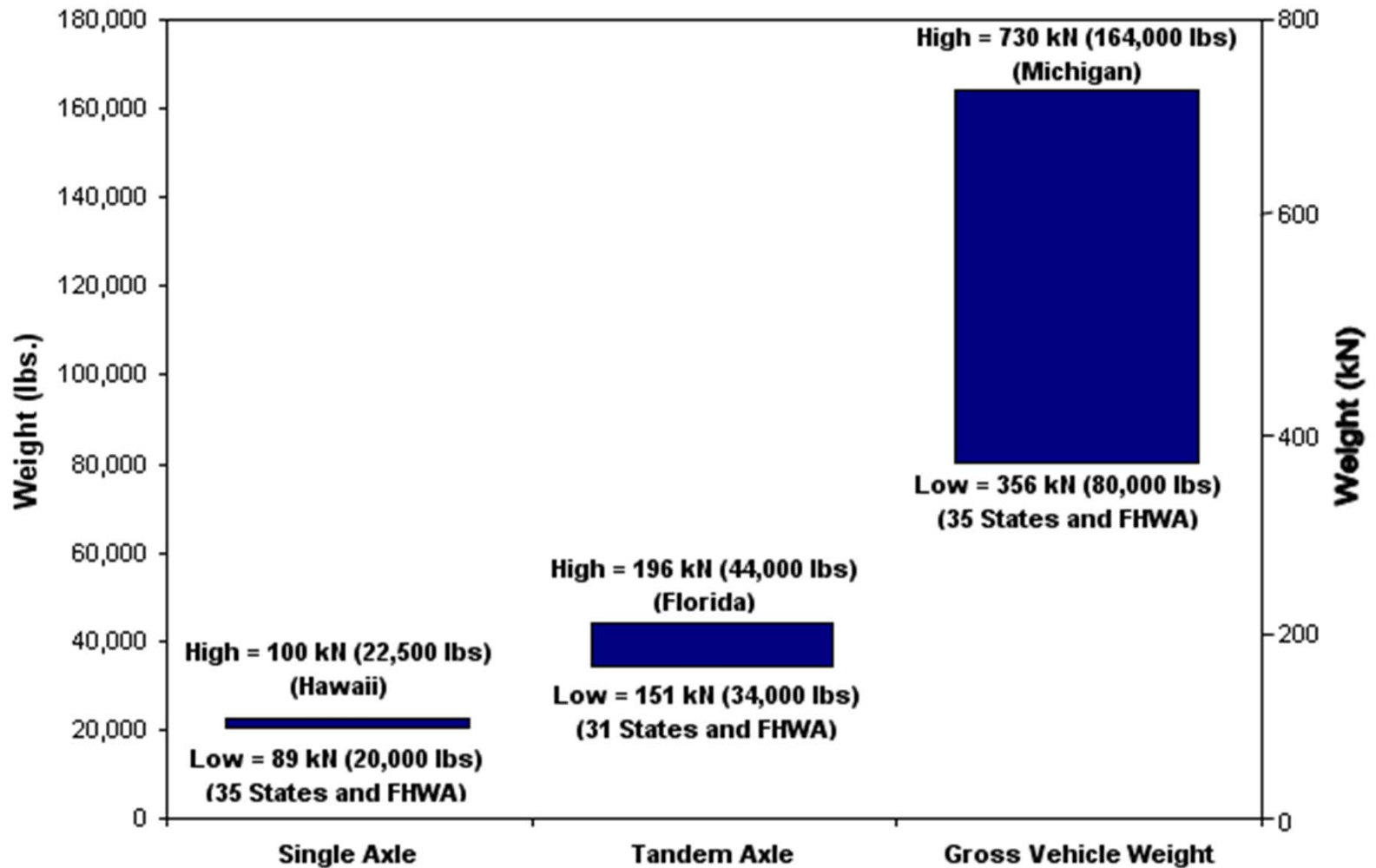


Tandem Axle



Tridem Axle

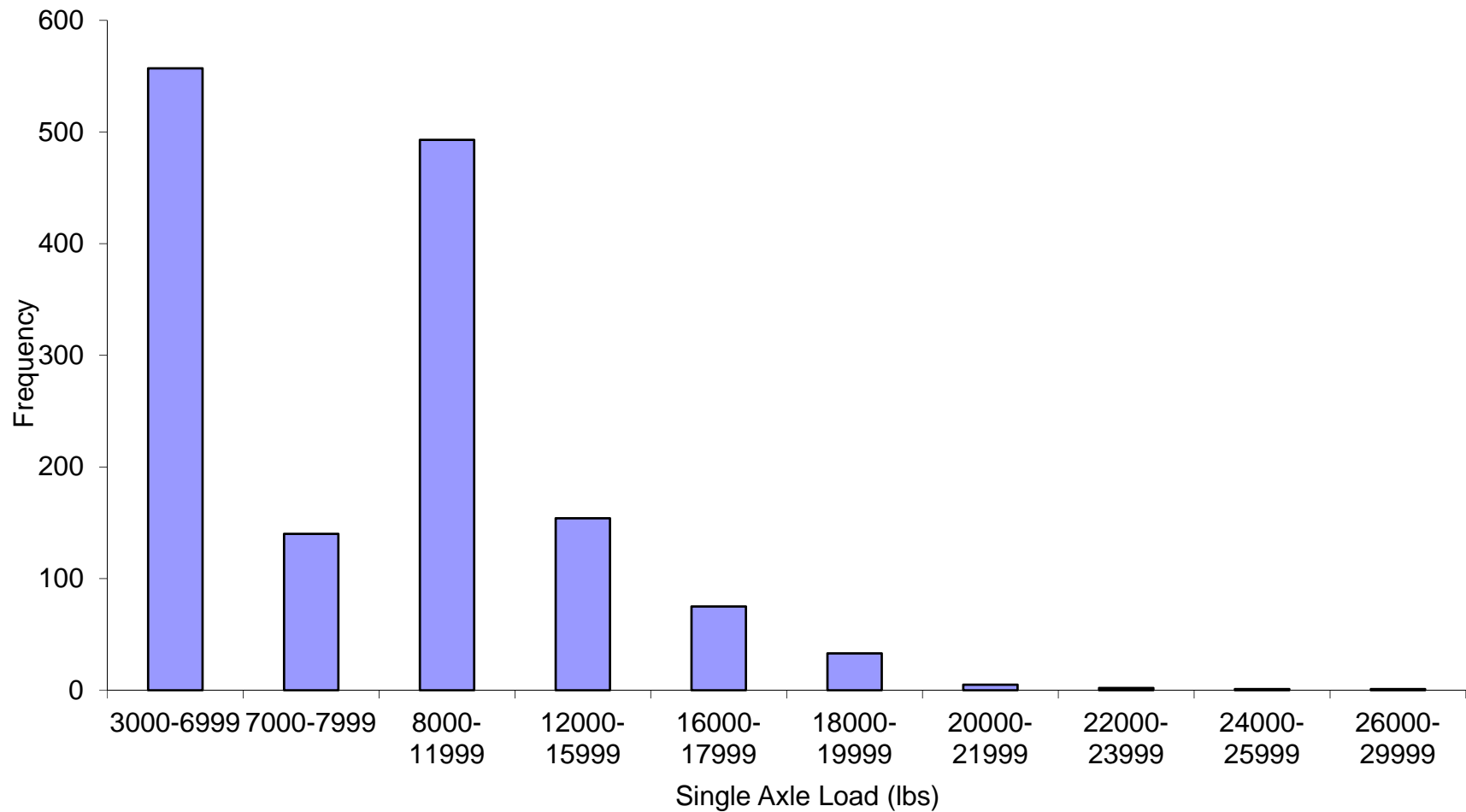
Typical Weight Limits



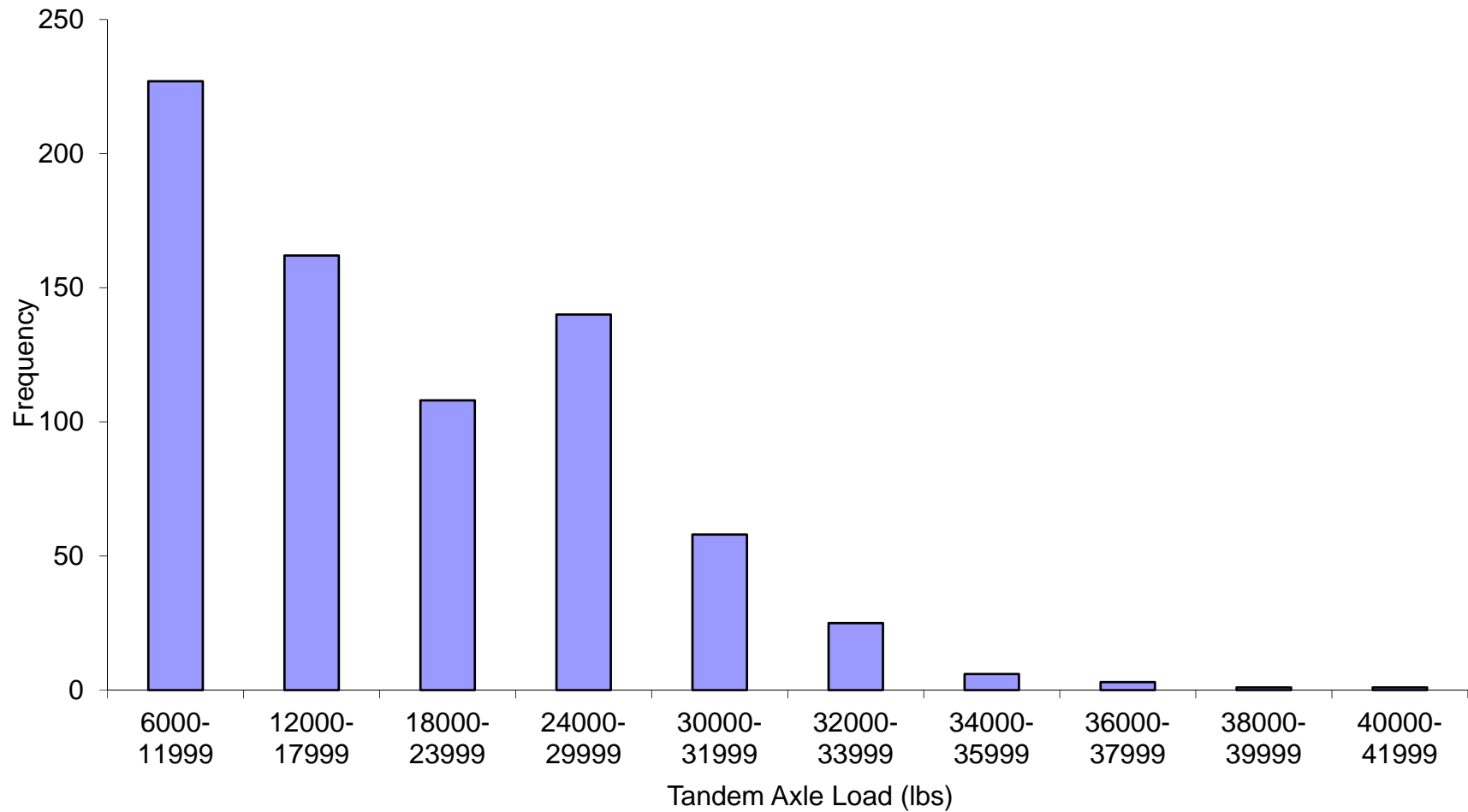
Weigh Stations



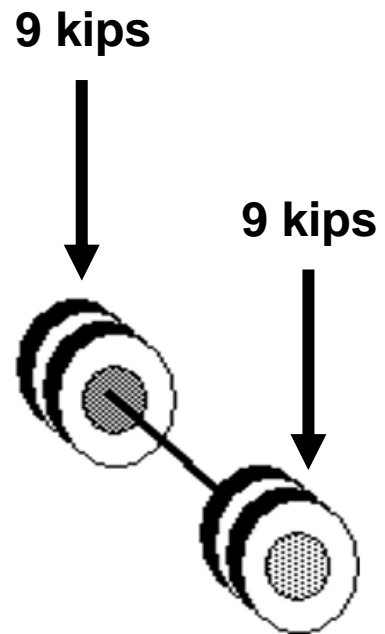
Axle Load Histogram



Axle Load Histogram



Standard Axle Load



Single Axle, Dual Wheels

LOAD EQUIVALENCY

Mazda Miata



Curb weight = 2300 lb

$$d_M = \frac{1}{N_M} \text{ (consumption per passage)}$$

Assume $N_M = 12,000,000$

Ford Excursion

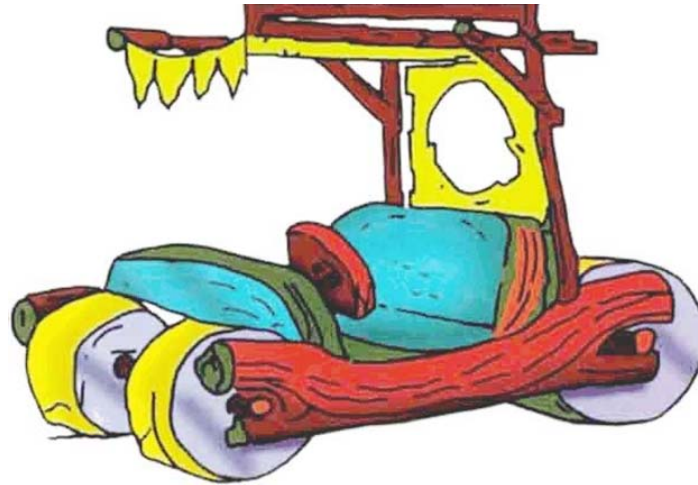


Curb weight = 6300 lb

$$d_F = \frac{1}{N_F} (\text{consumption per passage})$$

Assume $N_F = 200,000$

“Standard” Vehicle



Curb weight = 4300 lb

$$d_s = \frac{1}{N_s} (\text{consumption per passage})$$

Assume $N_F = 1,000,000$

Mazda Equivalency Factor

$$F_M = \frac{d_M}{d_S} = \frac{1/N_M}{1/N_S} = \frac{N_S}{N_M}$$

$$F_M = \frac{1,000,000}{12,000,000} = 0.083$$

Ford Equivalency Factor

$$F_F = \frac{d_F}{d_S} = \frac{1/N_F}{1/N_S} = \frac{N_S}{N_F}$$

$$F_F = \frac{1,000,000}{200,000} = 5.0$$

MECHANISTIC METHOD

Pavement Life (Fatigue)

$$N_f = k_1 \epsilon_t^{-k_2}$$



Asphalt
Fatigue
Life



Asphalt
Tensile
Strain

LEF (Fatigue)

$$LEF_i = \frac{N_s}{N_i} = \frac{\cancel{k_1} (\epsilon_t^s)^{-k_2}}{\cancel{k_1} (\epsilon_t^i)^{-k_2}} = \left(\frac{\epsilon_t^i}{\epsilon_t^s} \right)^{k_2}$$

$$3 \leq k_2 \leq 6$$

Pavement Life (Rutting)

$$N_f = k_3 \epsilon_c^{-k_4}$$

↑
Subgrade
Fatigue
Life

↑
Subgrade
Compressive
Strain

LEF (Rutting)

$$LEF_i = \frac{N_s}{N_i} = \frac{\cancel{k_3} (\epsilon_c^s)^{-k_4}}{\cancel{k_3} (\epsilon_c^i)^{-k_4}} = \left(\frac{\epsilon_c^i}{\epsilon_c^s} \right)^{k_4}$$

$$3.5 \leq k_4 \leq 4.5$$

Pavement Life (Rigid)

$$N_f = 225,000 \left(\frac{\sigma_t}{MOR} \right)^{-4}$$

Concrete
Tensile Strain

Concrete
Modulus of
Rupture

LEF (Rigid)

$$LEF_i = \frac{N_s}{N_i} = \frac{\left(\sigma_t^s / \cancel{MOR}\right)^{-4}}{\left(\sigma_t^i / \cancel{MOR}\right)^{-4}} = \left(\frac{\sigma_t^i}{\sigma_t^s}\right)^4$$

LEF Summary

$$LEF_i \approx \left(\frac{\sigma_t^i}{\sigma_t^s} \right)^4 \approx \left(\frac{\epsilon_t^i}{\epsilon_t^s} \right)^4 \approx \left(\frac{\epsilon_c^i}{\epsilon_c^s} \right)^4 \approx \left(\frac{L_i}{L_{18}} \right)^4$$

Measured
Axle Load



18-kip
Standard
Axle Load



AASHTO METHOD

AASHTO LEF

Flexible Pavements

$$\log \left[\frac{W_{t_x}}{W_{t_{18}}} \right] = 4.79 \log_{10} \frac{18+1}{L_x + L_2} + 4.33 \log_{10} L_2 + \frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}$$

Rigid Pavements

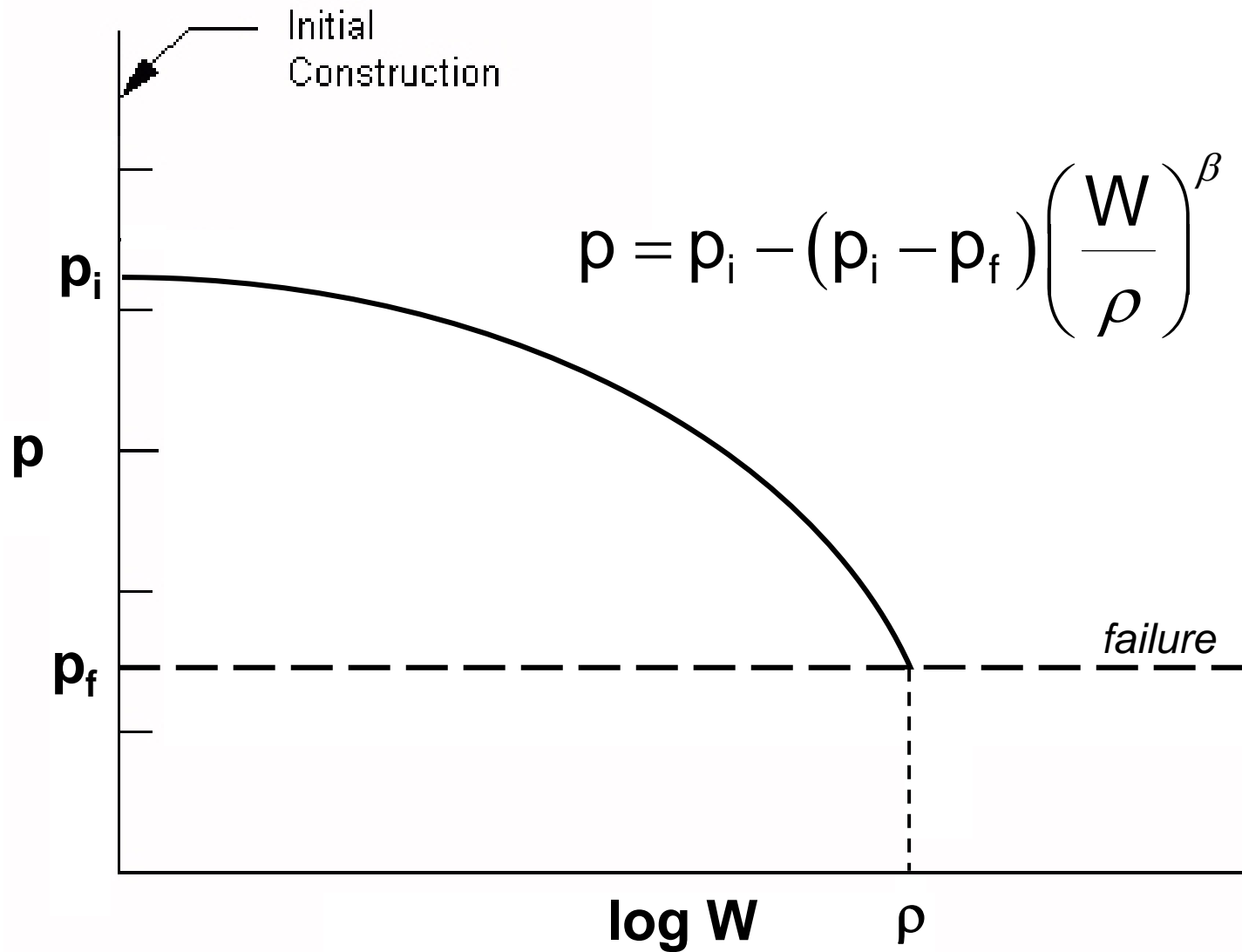
$$\log \left[\frac{W_{t_x}}{W_{t_{18}}} \right] = 4.62 \log_{10} \frac{18+1}{L_x + L_2} + 3.28 \log_{10} L_2 + \frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}$$

AASHO Road Test

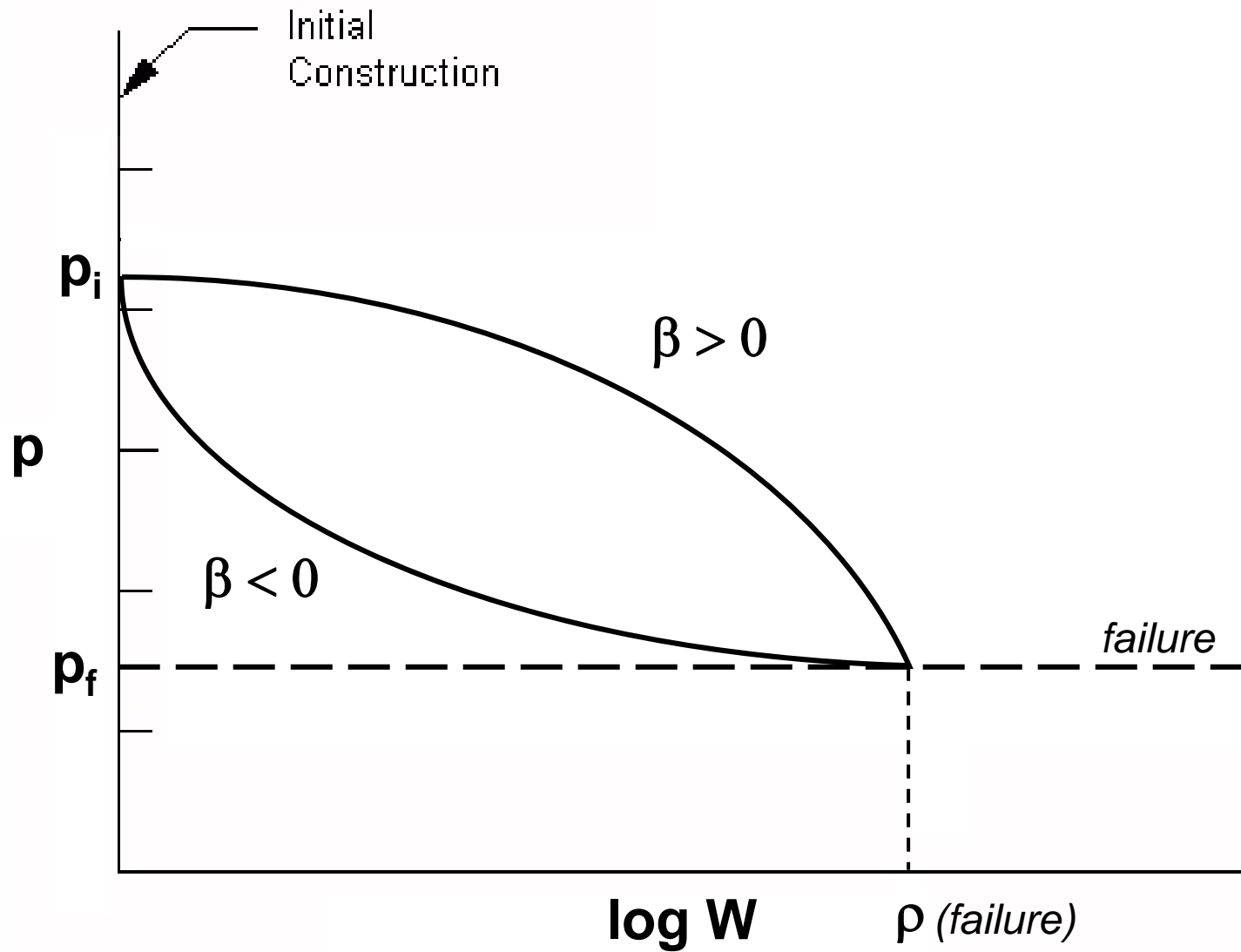


Source: <http://www.fhwa.dot.gov>

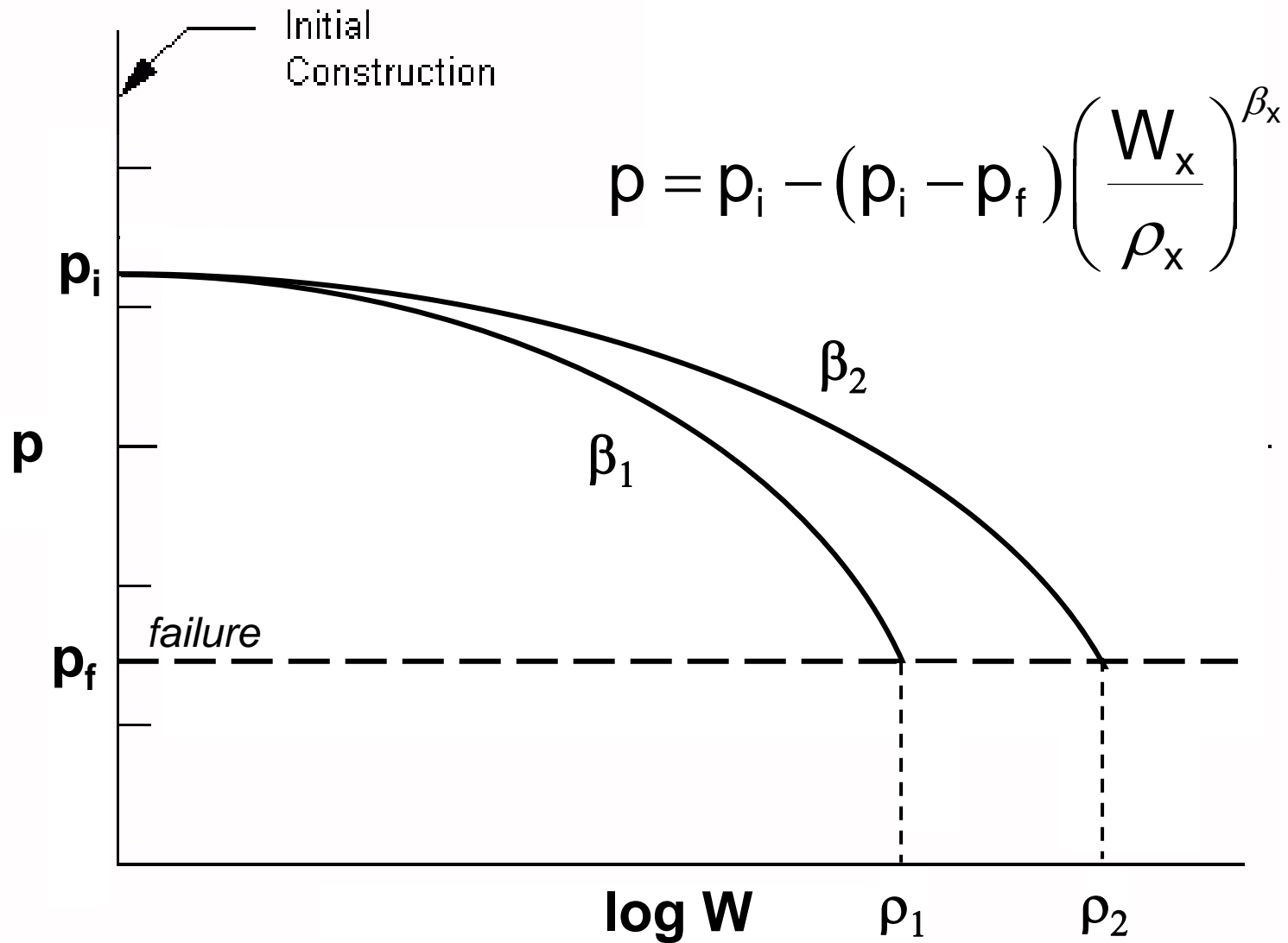
Pavement Performance



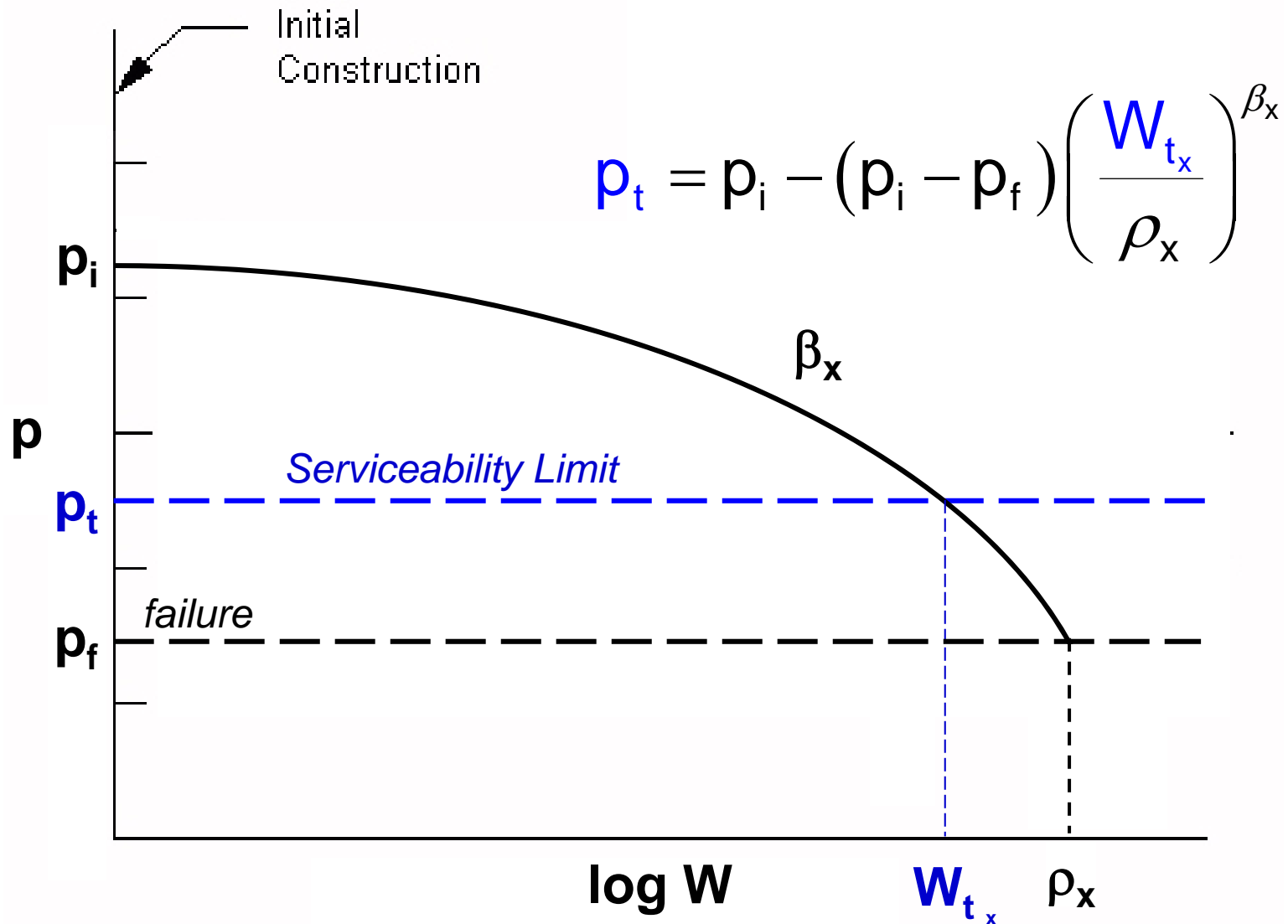
Pavement Performance



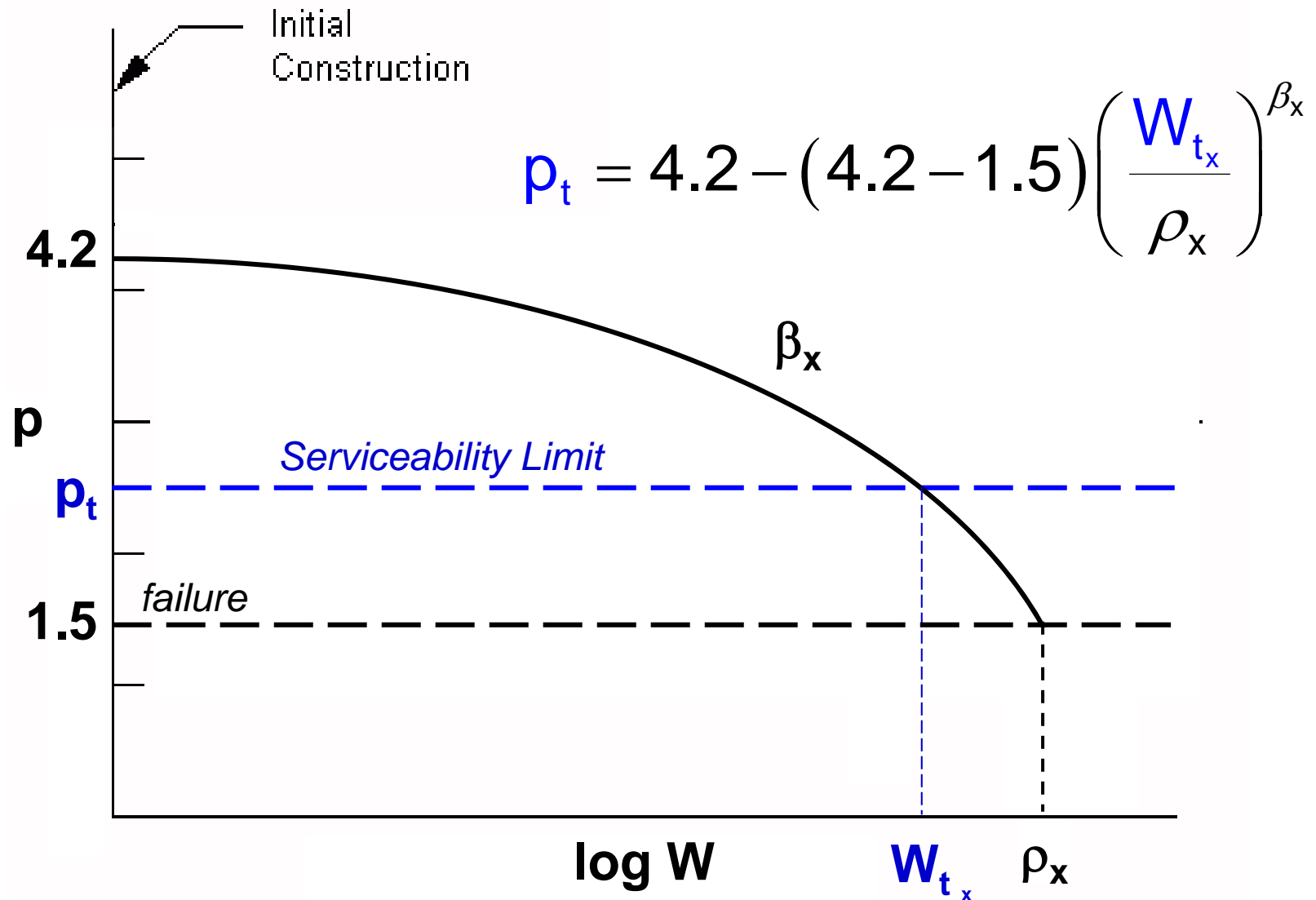
Pavement Performance



Pavement Performance



Flexible Pavement Performance



Flexible Pavement Performance

$$p_t = 4.2 - (4.2 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\beta_x = 0.4 + \frac{0.081(L_x + L_2)^{3.23}}{(SN + 1)^{5.19} L_2^{3.23}}$$

$$\rho_x = \frac{10^{5.93} (SN + 1)^{9.36} L_2^{4.33}}{(L_x + L_2)^{4.79}}$$

Example

Calculate the serviceability index p_t for a flexible pavement with a structural number of 6 that has been subjected to 20 million 18-kip axle loads.

Step 1

Calculate ρ_{18} (the number of 18-kip single-axle loads needed to reach the $p_f = 1.5$ failure limit):

$$\begin{aligned}\rho_x &= \frac{10^{5.93} (SN + 1)^{9.36} L_2^{4.33}}{(L_x + L_2)^{4.79}} \\ &= \frac{10^{5.93} (6 + 1)^{9.36} (1)^{4.33}}{(18 + 1)^{4.79}} = 51,866,615\end{aligned}$$

Step 2

Calculate β_{18} (the rate at which the performance curve will approach $\rho_{18} = 51,866,615$ axle loads):

$$\begin{aligned}\beta_x &= 0.4 + \frac{0.081(L_x + L_2)^{3.23}}{(SN + 1)^{5.19} L_2^{3.23}} \\ &= 0.4 + \frac{0.081(18 + 1)^{3.23}}{(6 + 1)^{5.19} (1)^{3.23}} = 0.445\end{aligned}$$

Step 3

Calculate the performance index p_t after 20 million 18-kip loads have been applied to the pavement:

$$\begin{aligned} p_t &= 4.2 - (4.2 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x} \\ &= 4.2 - 2.7 \left(\frac{20,000,000}{51,866,615} \right)^{0.445} = 2.43 \end{aligned}$$

Flexible Pavement Performance

$$p_t = 4.2 - (4.2 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$



$$W_{t_x} = f(p_t, \beta_x, \rho_x)$$

AASHTO LEF

$$LEF = \frac{N_s}{N_x} = \frac{W_{t_{18}}}{W_{t_x}} = \frac{f(p_t, \beta_{18}, \rho_{18})}{f(p_t, \beta_x, \rho_x)}$$

Flexible Pavement Performance

$$p_t = 4.2 - (4.2 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\frac{4.2 - p_t}{4.2 - 1.5} = \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\underbrace{\log_{10} \left(\frac{4.2 - p_t}{4.2 - 1.5} \right)}_{G_t} = \beta_x \log_{10} \left(\frac{W_{t_x}}{\rho_x} \right)$$

Pavement Performance

$$G_t = \beta_x \log_{10} \left(\frac{W_{t_x}}{\rho_x} \right)$$

$$\frac{G_t}{\beta_x} = \log_{10} W_{t_x} - \log_{10} \rho_x$$

$$\log_{10} W_{t_x} = \log_{10} \rho_x + \frac{G_t}{\beta_x}$$

Pavement Performance

$$\log_{10} W_{t_x} = \log_{10} \rho_x + \frac{G_t}{\beta_x}$$

$$10^{\log_{10} W_{t_x}} = 10^{\log_{10} \rho_x + \frac{G_t}{\beta_x}}$$

$$W_{t_x} = \rho_x 10^{\frac{G_t}{\beta_x}}$$

Example

How many 18-kip axle loads are needed to reduce the serviceability index of a flexible pavement with a Structural Number of 5 from $p_i = 4.5$ to $p_t = 2.5$?

Step 1

Calculate ρ_{18} (the number of 18-kip single-axle loads needed to reach the $p_f = 1.5$ failure limit):

$$\begin{aligned}\rho_x &= \frac{10^{5.93} (SN + 1)^{9.36} L_2^{4.33}}{(L_x + L_2)^{4.79}} \\ &= \frac{10^{5.93} (5 + 1)^{9.36} (1)^{4.33}}{(18 + 1)^{4.79}} = 12,253,664\end{aligned}$$

Step 2

Calculate β_{18} (the rate at which the performance curve will approach $\rho_{18} = 12,253,664$ axle loads):

$$\begin{aligned}\beta_x &= 0.4 + \frac{0.081(L_x + L_2)^{3.23}}{(SN + 1)^{5.19} L_2^{3.23}} \\ &= 0.4 + \frac{0.081(18 + 1)^{3.23}}{(5 + 1)^{5.19} (1)^{3.23}} = 0.500\end{aligned}$$

Step 3

Calculate W_{18} (the number of 18-kip axle loads) needed to reach a serviceability limit of $p_t = 2.5$:

$$\begin{aligned} W_{t_{18}} &= \rho_{18} 10^{\frac{G_t}{\beta_{18}}} = \rho_{18} 10^{\frac{\log_{10}\left(\frac{4.2-p_t}{4.2-1.5}\right)}{\beta_{18}}} \\ &= 12,253,664 \times 10^{\frac{\log_{10}\left(\frac{4.2-2.5}{4.2-1.5}\right)}{0.500}} = 4,857,763 \end{aligned}$$

Question

How many 12-kip axle loads are needed to reduce the serviceability index to the same $p_t = 2.5$ limit?

Step 1

Calculate ρ_{12} (the number of 12-kip single-axle loads needed to reach the $p_f = 1.5$ failure limit):

$$\begin{aligned}\rho_x &= \frac{10^{5.93} (SN + 1)^{9.36} L_2^{4.33}}{(L_x + L_2)^{4.79}} \\ &= \frac{10^{5.93} (5 + 1)^{9.36} (1)^{4.33}}{(12 + 1)^{4.79}} = 75,458,305\end{aligned}$$

Step 2

Calculate β_{12} (the rate at which the performance curve will approach $\rho_{12} = 74,458,305$ axle loads):

$$\begin{aligned}\beta_x &= 0.4 + \frac{0.081(L_x + L_2)^{3.23}}{(SN + 1)^{5.19} L_2^{3.23}} \\ &= 0.4 + \frac{0.081(12 + 1)^{3.23}}{(5 + 1)^{5.19} (1)^{3.23}} = 0.429\end{aligned}$$

Step 3

Calculate $W_{t_{12}}$ (the number of 12-kip axle loads) needed to reach a serviceability limit of $p_t = 2.5$:

$$\begin{aligned} W_{t_{12}} &= \rho_{12} 10^{\frac{G_t}{\beta_{12}}} = \rho_{12} 10^{\frac{\log_{10}\left(\frac{4.2-p_t}{4.2-1.5}\right)}{\beta_{12}}} \\ &= 75,458,305 \times 10^{\frac{\log_{10}\left(\frac{4.2-2.5}{4.2-1.5}\right)}{0.429}} = 25,666,939 \end{aligned}$$

Question

What is the LEF for a 12-kip single axle load applied to a pavement with SN = 5 if $p_t = 2.5$?

$$LEF = \frac{W_{t_{18}}}{W_{t_{12}}} = \frac{4,857,763}{25,666,939} = 0.189$$

AASHTO LEF

$$W_{t_x} = \rho_x 10^{G_t/\beta_x}$$

$$LEF = \frac{W_{t_{18}}}{W_{t_x}} = \frac{\rho_{18} 10^{G_t/\beta_{18}}}{\rho_x 10^{G_t/\beta_x}} = \frac{\rho_{18}}{\rho_x} \times 10^{\left(\frac{G_t}{\beta_{18}} - \frac{G_t}{\beta_x}\right)}$$

$$LEF \equiv e_x \equiv EALF$$

AASHTO LEF

$$LEF = \frac{W_{t_{18}}}{W_{t_x}} = \frac{\rho_{18}}{\rho_x} \times 10^{\left(\frac{G_t}{\beta_{18}} - \frac{G_t}{\beta_x}\right)}$$

$$\frac{1}{LEF} = \frac{W_{t_x}}{W_{t_{18}}} = \frac{\rho_x}{\rho_{18}} \times 10^{\left(\frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}\right)}$$

AASHTO LEF

This is basically the equation in the textbook

$$\log \left[\frac{W_{t_x}}{W_{t_{18}}} \right] = \log \rho_x - \log \rho_{18} + \frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}$$

NOTE : this is $\log \left(\frac{1}{e_x} \right)$ not e_x

AASHTO LEF

Flexible Pavements

$$\log \left[\frac{W_{t_x}}{W_{t_{18}}} \right] = 4.79 \log_{10} \frac{18+1}{L_x + L_2} + 4.33 \log_{10} L_2 + \frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}$$

Rigid Pavements

$$\log \left[\frac{W_{t_x}}{W_{t_{18}}} \right] = 4.62 \log_{10} \frac{18+1}{L_x + L_2} + 3.28 \log_{10} L_2 + \frac{G_t}{\beta_x} - \frac{G_t}{\beta_{18}}$$

Rigid Pavement Performance

$$p_t = 4.5 - (4.5 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\beta_x = 1.0 + \frac{3.63 (L_x + L_2)^{5.20}}{(D + 1)^{8.46} L_2^{3.52}}$$

$$\rho_x = \frac{10^{5.85} (D + 1)^{7.35} L_2^{3.28}}{(L_x + L_2)^{4.62}}$$

Rigid Pavement Performance

$$p_t = 4.5 - (4.5 - 1.5) \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\frac{4.5 - p_t}{4.5 - 1.5} = \left(\frac{W_{t_x}}{\rho_x} \right)^{\beta_x}$$

$$\underbrace{\log_{10} \left(\frac{4.5 - p_t}{4.5 - 1.5} \right)}_{G_t} = \beta_x \log_{10} \left(\frac{W_{t_x}}{\rho_x} \right)$$

TRUCK LOAD FACTORS

Question

What is the LEF for a 12-kip single axle load applied to a pavement with SN = 5 if $p_t = 2.5$?

$$LEF = \frac{W_{t_{18}}}{W_{t_{12}}} = \frac{4,857,763}{25,666,939} = 0.189$$

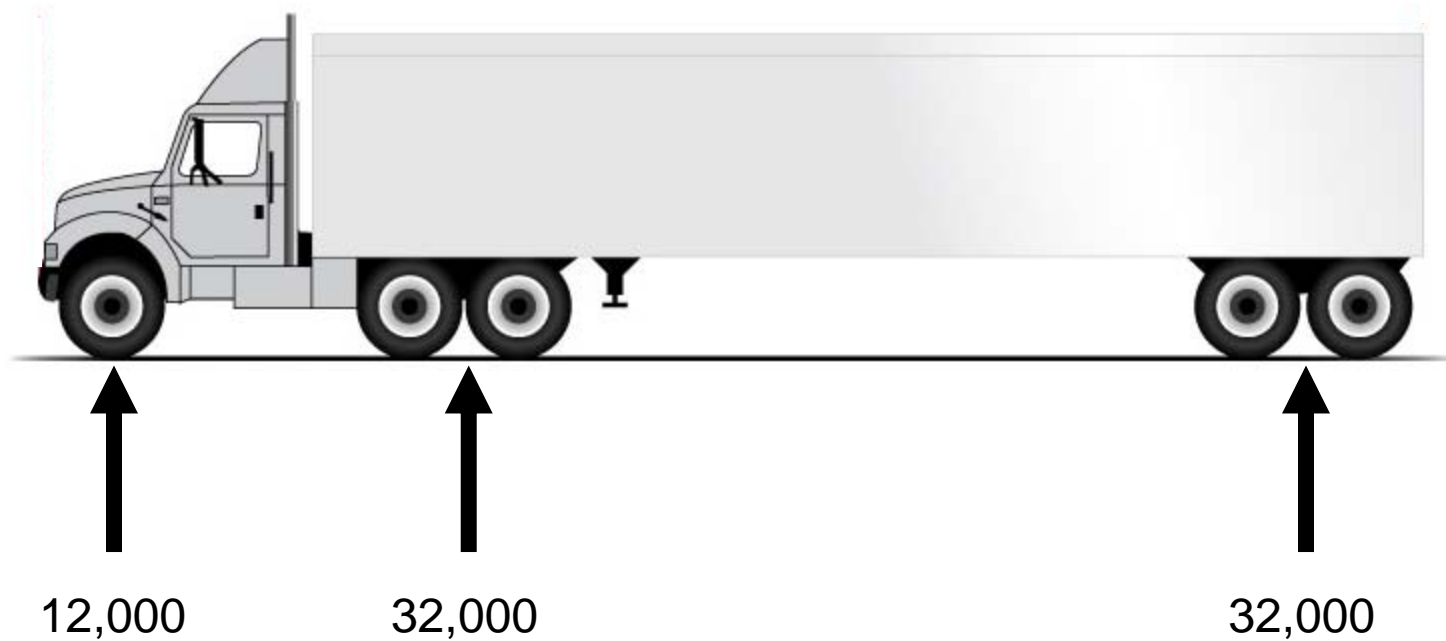
AASHTO Equivalency Factors

| Gross Axle Load | | Load Equivalency Factors | | Gross Axle Load | | Load Equivalency Factors | |
|-----------------|---------------|--------------------------|---------------|-----------------|---------------|--------------------------|--------------|
| kN | lb | Single Axles | Tandem Axles | kN | lb | Single Axles | Tandem Axles |
| 4.45 | 1,000 | 0.00002 | | 187.0 | 42,000 | 25.64 | 2.51 |
| 8.9 | 2,000 | 0.00018 | | 195.7 | 44,000 | 31.00 | 3.00 |
| 17.8 | 4,000 | 0.00209 | | 200.0 | 45,000 | 34.00 | 3.27 |
| 22.25 | 5,000 | 0.00500 | | 204.5 | 46,000 | 37.24 | 3.55 |
| 26.7 | 6,000 | 0.01043 | | 213.5 | 48,000 | 44.50 | 4.17 |
| 35.6 | 8,000 | 0.0343 | | 222.4 | 50,000 | 52.88 | 4.86 |
| 44.5 | 10,000 | 0.0877 | 0.00688 | 231.3 | 52,000 | | 5.63 |
| 53.4 | 12,000 | 0.189 | 0.0144 | 240.2 | 54,000 | | 6.47 |
| 62.3 | 14,000 | 0.360 | 0.0270 | 244.6 | 55,000 | | 6.93 |
| 66.7 | 15,000 | 0.478 | 0.0360 | 249.0 | 56,000 | | 7.41 |
| 71.2 | 16,000 | 0.623 | 0.0472 | 258.0 | 58,000 | | 8.45 |
| 80.0 | 18,000 | 1.000 | 0.0773 | 267.0 | 60,000 | | 9.59 |
| 89.0 | 20,000 | 1.51 | 0.1206 | 275.8 | 62,000 | | 10.84 |
| 97.8 | 22,000 | 2.18 | 0.180 | 284.5 | 64,000 | | 12.22 |
| 106.8 | 24,000 | 3.03 | 0.260 | 289.0 | 65,000 | | 12.96 |
| 111.2 | 25,000 | 3.53 | 0.308 | 293.5 | 66,000 | | 13.73 |
| 115.6 | 26,000 | 4.09 | 0.364 | 302.5 | 68,000 | | 15.38 |
| 124.5 | 28,000 | 5.39 | 0.495 | 311.5 | 70,000 | | 17.19 |
| 133.5 | 30,000 | 6.97 | 0.658 | 320.0 | 72,000 | | 19.16 |
| 142.3 | 32,000 | 8.88 | 0.857 | 329.0 | 74,000 | | 21.32 |
| 151.2 | 34,000 | 11.18 | 1.095 | 333.5 | 75,000 | | 22.47 |
| 155.7 | 35,000 | 12.50 | 1.23 | 338.0 | 76,000 | | 23.66 |
| 160.0 | 36,000 | 13.93 | 1.38 | 347.0 | 78,000 | | 26.22 |
| 169.0 | 38,000 | 17.20 | 1.70 | 356.0 | 80,000 | | 28.99 |
| 178.0 | 40,000 | 21.08 | 2.08 | | | | |

Note: kN converted to lb are within 0.1 percent of lb shown.

NOTE: This table is for SN = 5.0 and $p_t = 2.5$ ONLY

Individual Truck Load Factors



ESAL = ??

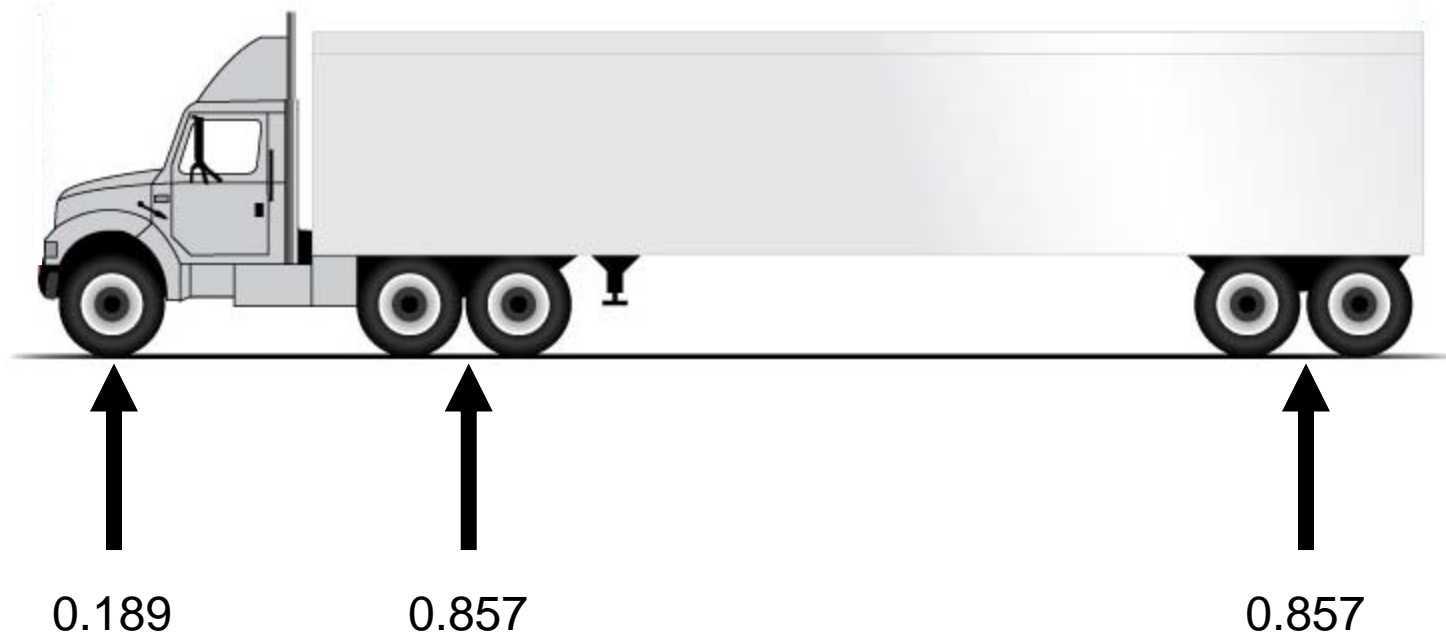
AASHTO Equivalency Factors

| Gross Axle Load | | Load Equivalency Factors | | Gross Axle Load | | Load Equivalency Factors | |
|-----------------|---------------|--------------------------|---------------|-----------------|---------------|--------------------------|--------------|
| kN | lb | Single Axles | Tandem Axles | kN | lb | Single Axles | Tandem Axles |
| 4.45 | 1,000 | 0.00002 | | 187.0 | 42,000 | 25.64 | 2.51 |
| 8.9 | 2,000 | 0.00018 | | 195.7 | 44,000 | 31.00 | 3.00 |
| 17.8 | 4,000 | 0.00209 | | 200.0 | 45,000 | 34.00 | 3.27 |
| 22.25 | 5,000 | 0.00500 | | 204.5 | 46,000 | 37.24 | 3.55 |
| 26.7 | 6,000 | 0.01043 | | 213.5 | 48,000 | 44.50 | 4.17 |
| 35.6 | 8,000 | 0.0343 | | 222.4 | 50,000 | 52.88 | 4.86 |
| 44.5 | 10,000 | 0.0877 | 0.00688 | 231.3 | 52,000 | | 5.63 |
| 53.4 | 12,000 | 0.189 | 0.0144 | 240.2 | 54,000 | | 6.47 |
| 62.3 | 14,000 | 0.360 | 0.0270 | 244.6 | 55,000 | | 6.93 |
| 66.7 | 15,000 | 0.478 | 0.0360 | 249.0 | 56,000 | | 7.41 |
| 71.2 | 16,000 | 0.623 | 0.0472 | 258.0 | 58,000 | | 8.45 |
| 80.0 | 18,000 | 1.000 | 0.0773 | 267.0 | 60,000 | | 9.59 |
| 89.0 | 20,000 | 1.51 | 0.1206 | 275.8 | 62,000 | | 10.84 |
| 97.8 | 22,000 | 2.18 | 0.180 | 284.5 | 64,000 | | 12.22 |
| 106.8 | 24,000 | 3.03 | 0.260 | 289.0 | 65,000 | | 12.96 |
| 111.2 | 25,000 | 3.53 | 0.308 | 293.5 | 66,000 | | 13.73 |
| 115.6 | 26,000 | 4.09 | 0.364 | 302.5 | 68,000 | | 15.38 |
| 124.5 | 28,000 | 5.39 | 0.495 | 311.5 | 70,000 | | 17.19 |
| 133.5 | 30,000 | 6.97 | 0.658 | 320.0 | 72,000 | | 19.16 |
| 142.3 | 32,000 | 8.88 | 0.857 | 329.0 | 74,000 | | 21.32 |
| 151.2 | 34,000 | 11.18 | 1.095 | 333.5 | 75,000 | | 22.47 |
| 155.7 | 35,000 | 12.50 | 1.23 | 338.0 | 76,000 | | 23.66 |
| 160.0 | 36,000 | 13.93 | 1.38 | 347.0 | 78,000 | | 26.22 |
| 169.0 | 38,000 | 17.20 | 1.70 | 356.0 | 80,000 | | 28.99 |
| 178.0 | 40,000 | 21.08 | 2.08 | | | | |

Note: kN converted to lb are within 0.1 percent of lb shown.

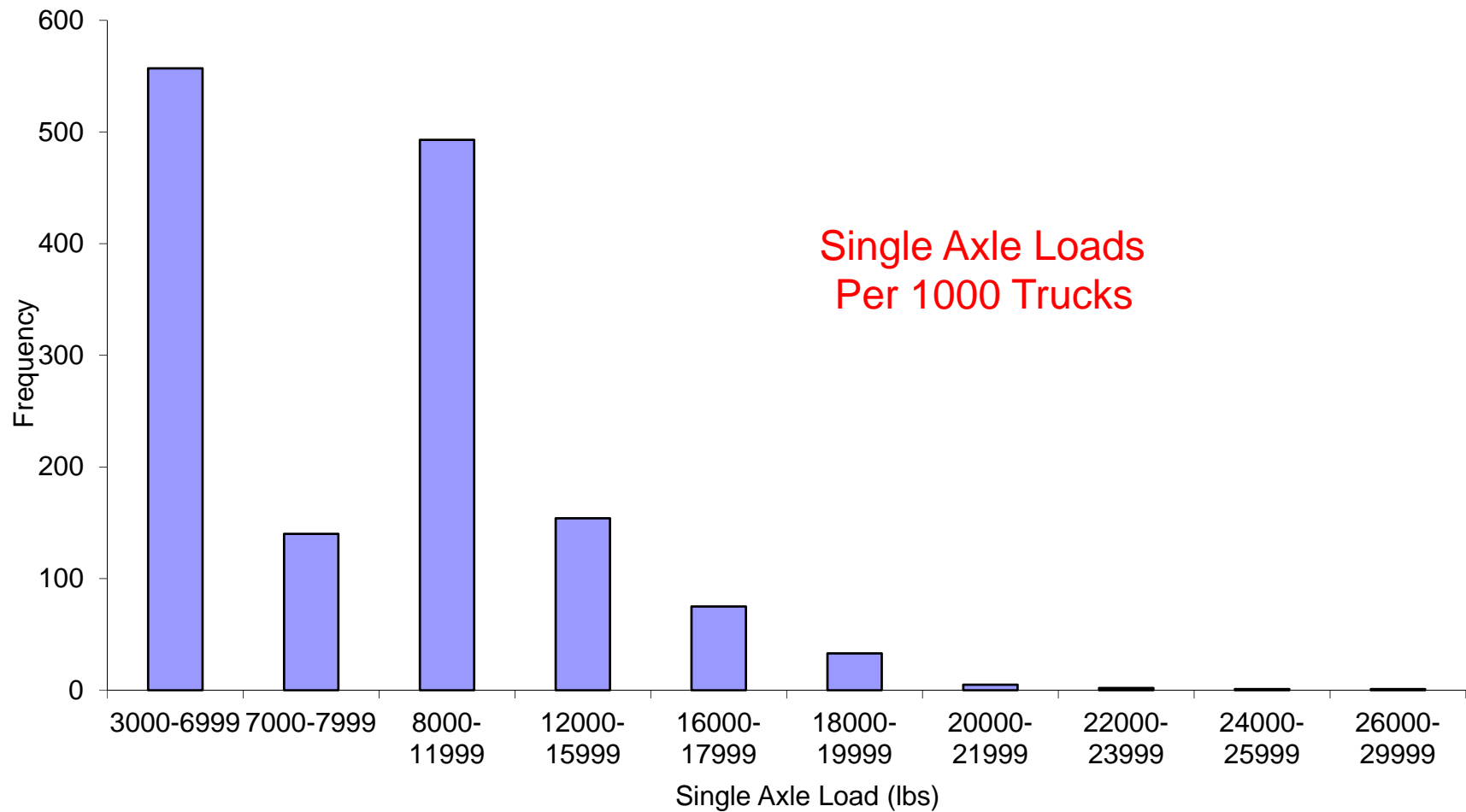
NOTE: This table is for SN = 5.0 and $p_t = 2.5$ ONLY

Individual Truck Load Factors

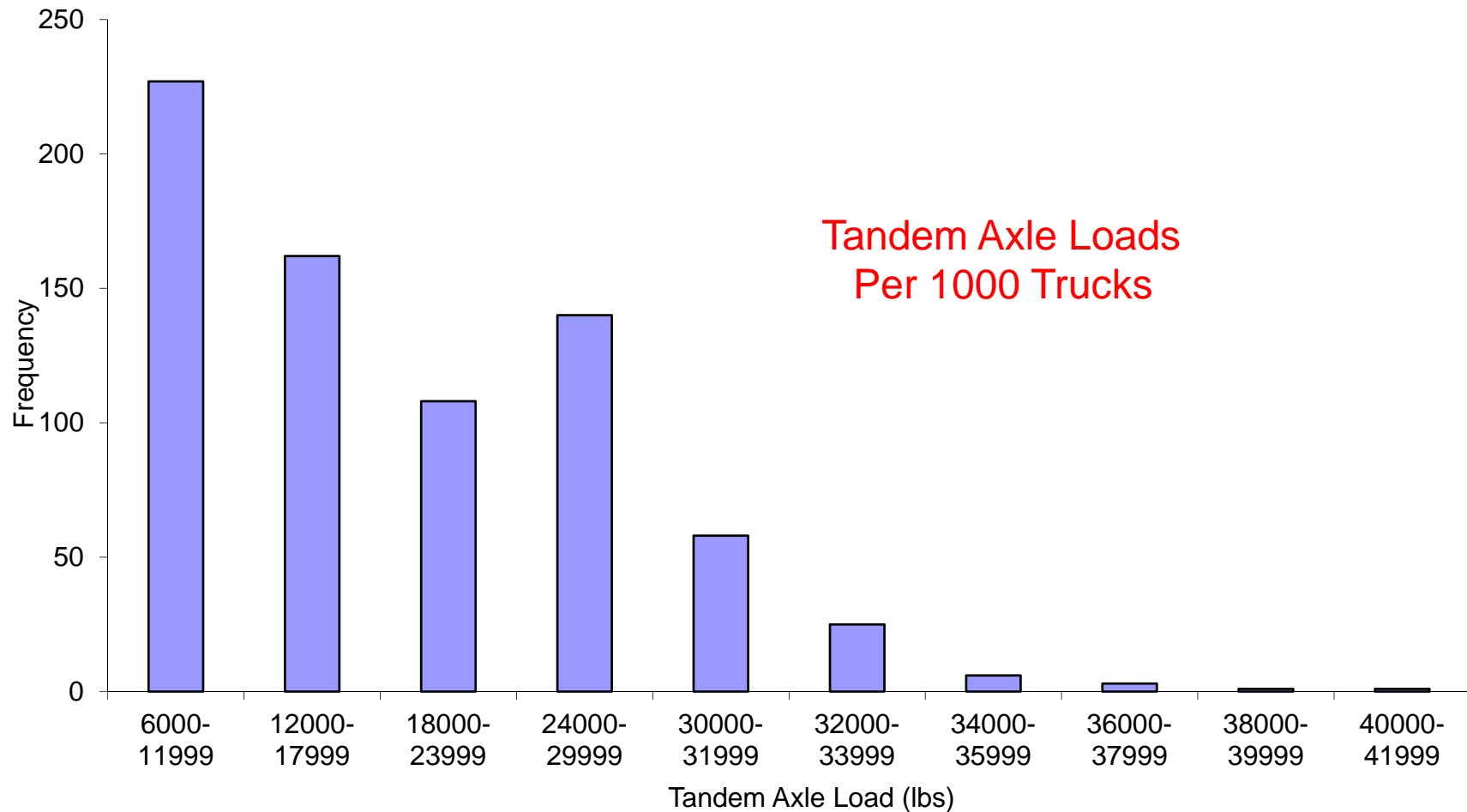


$$\text{ESAL} = 1.903$$

Average Truck Load Factors



Average Truck Load Factors



Single Axles

| Load Group (lbs) | Axle Count per 1000 trucks | LEF | ESALs |
|---------------------|-------------------------------|---------|-------|
| 3000-6999 | 557 | 0.005 | 2.79 |
| 7000-7999 | 140 | 0.027 | 3.78 |
| 8000-11999 | 493 | 0.088 | 43.38 |
| 12000-15999 | 154 | 0.360 | 55.44 |
| 16000-17999 | 75 | 0.796 | 59.70 |
| 18000-19999 | 33 | 1.24 | 40.9 |
| 20000-21999 | 5 | 1.83 | 9.15 |
| 22000-23999 | 2 | 2.58 | 5.16 |
| 24000-25999 | 1 | 3.53 | 3.53 |
| 26000-29999 | 1 | 5.39 | 5.39 |
| | | TOTAL = | 229.2 |

Tandem Axles

| Load Group (kips) | Axle Count per 1000 trucks | LEF | ESALs |
|----------------------|-------------------------------|---------|-------|
| 6000-11999 | 227 | 0.010 | 2.3 |
| 12000-17999 | 162 | 0.037 | 6.0 |
| 18000-23999 | 108 | 0.150 | 16.2 |
| 24000-29999 | 140 | 0.429 | 60.1 |
| 30000-31999 | 58 | 0.757 | 43.9 |
| 32000-33999 | 25 | 0.97 | 24.3 |
| 34000-35999 | 6 | 1.23 | 7.4 |
| 36000-37999 | 3 | 1.54 | 4.6 |
| 38000-39999 | 1 | 1.89 | 1.9 |
| 40000-41999 | 1 | 2.29 | 2.3 |
| | | TOTAL = | 169.0 |











Average Truck Load Factor

$$T_f = \frac{ESALs}{Vehicles} = \frac{229 + 169}{1000} = 0.40$$

Average number of ESALs per truck

SIMPLIFIED METHODS

FHWA Truck Classes

| Vehicle Class | Schema | Description |
|---------------|---|---|
| 4 |  | Buses |
| 5 |  | Two-axle, six-tire, single-unit trucks |
| 6 |  | Three-axle single-unit trucks |
| 7 |  | Four- or more than four-axle single-unit trucks |
| 8 |  | Four- or less than four-axle single trailer trucks |
| 9 |  | Five-axle single trailer trucks |
| 10 |  | Six- or more than six-axle single trailer trucks |
| 11 |  | Five- or less than five-axle multi-trailer trucks |
| 12 |  | Six-axle multi-trailer trucks |
| 13 |  | Seven- or more than seven-axle multi-trailer trucks |

FHWA Class 4



Source: WSDOT Pavement Guide Interactive CD-ROM

FHWA Class 5



Source: WSDOT Pavement Guide Interactive CD-ROM

FHWA Class 6



FHWA Class 7



FHWA Class 8



Source: WSDOT Pavement Guide Interactive CD-ROM

FHWA Class 9



Source: images.encarta.msn.com

FHWA Class 10



Source: WSDOT Pavement Guide Interactive CD-ROM

FHWA Class 11

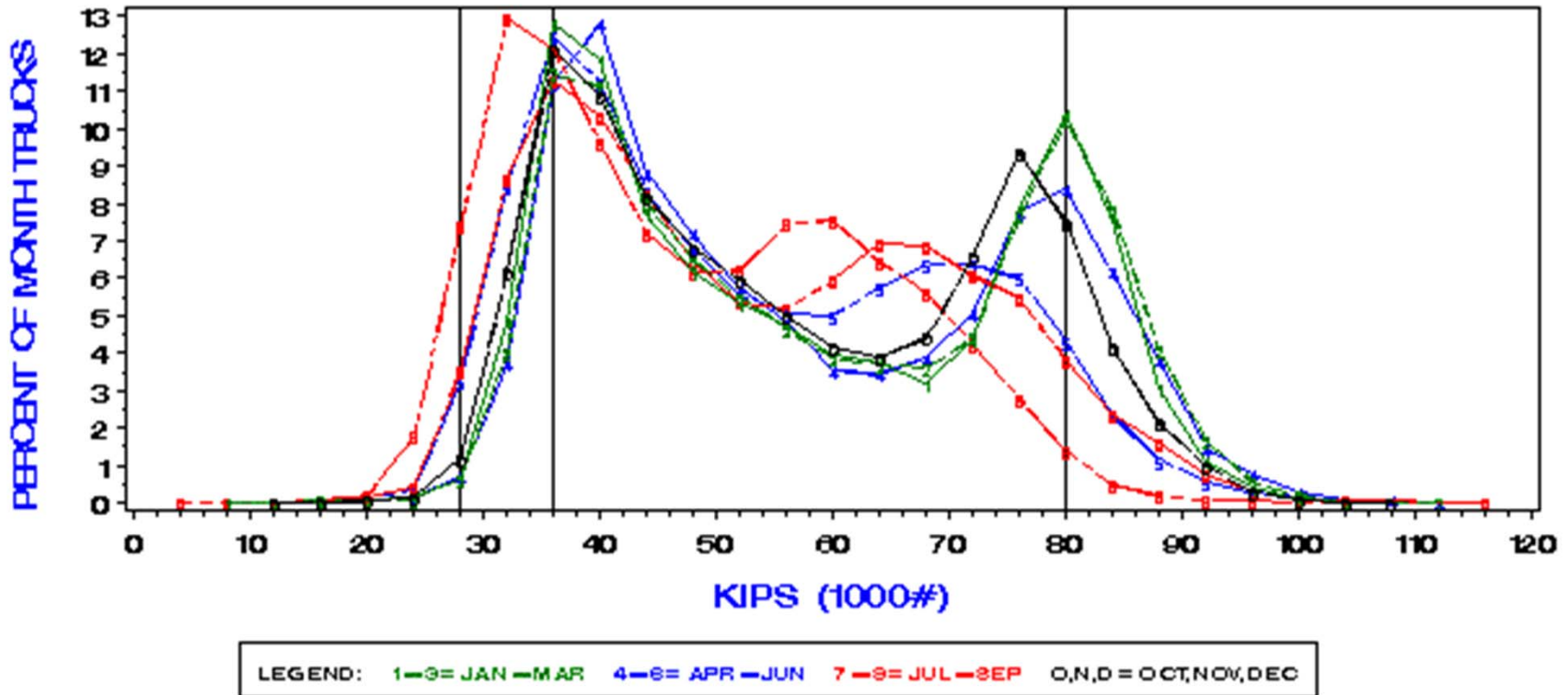


FHWA Truck Classes

| Class | Type | EALF |
|--------------|--|-------------|
| 1 | Motorcycles | negligible |
| 2 | Passenger Cars | negligible |
| 3 | Other Two-Axle, Four-Tire Single Unit Vehicles | negligible |
| 4 | Buses | 0.57 |
| 5 | Two-Axle, Six-Tire, Single Unit Trucks | 0.26 |
| 6 | Three-Axle Single Unit Trucks | 0.42 |
| 7 | Four or More Axle Single Unit Trucks | 0.42 |
| 8 | Four or Less Axle Single Trailer Trucks | 0.30 |
| 9 | Five-Axle Single Trailer Trucks | 1.20 |
| 10 | Six or More Axle Single Trailer Trucks | 0.93 |
| 11 | Five or Less Axle Multi-Trailer Trucks | 0.82 |
| 12 | Six-Axle Multi-Trailer Trucks | 1.06 |
| 13 | Seven or More Axle Multi-Trailer Trucks | 1.39 |

Typical Traffic Data

DISTRIBUTION OF GROSS WEIGHT 5-AXLE SEMIS BY STATION DIRECTION STA= P3S NAME= 185TH_ DIR= 5 LANE= 2 YY= 2002



Source: WSDOT Pavement Guide Interactive CD-ROM

WSDOT Simplified System

| WSDOT Category | FHWA Classes | Assumed EALF |
|--|--------------|--------------|
| Single Units | 4, 5, 6, 7 | 0.40 |
| Double Units | 8, 9, 10 | 1.00 |
| Trains | 11, 12, 13 | 1.75 |
| $\text{Daily ESALs} = 0.40(\text{single units}) + 1.00(\text{double units}) + 1.75(\text{trains})$ | | |

Source: WSDOT Pavement Guide Interactive CD-ROM

TDOT Simplified System

| Vehicle Type | FHWA Class | Flexible EALF | Rigid EALF |
|------------------------|------------|---------------|------------|
| Cars & Motorcycles | 1, 2 | 0.001 | 0.001 |
| Pickups, Panel Vans | 3 | 0.004 | 0.005 |
| Buses | 4 | 0.300 | 0.300 |
| 2-axle, 6-tire Singles | 5 | 0.170 | 0.170 |
| 3-axle or more Singles | 6, 7 | 0.700 | 1.000 |
| 4-axle Combos | 8 | 0.700 | 0.780 |
| 5-axle or more Combos | 9 -11 | 1.100 | 1.780 |

DESIGN ESALS

Design ESALS

- Goal is to determine how many ESALS will be applied to the most heavily used traffic lane over the design life of the pavement and design the entire pavement system for that level of traffic.

Design ESALS

$$\text{ESAL} = 365 (\text{ADT}) (\text{T}) (\text{T}_f) (\text{D}) (\text{L}) (\text{G})$$

Average Daily Traffic (two-way) ↓

Truck Load Factor ↓

Lane Distribution Factor ↓

Percent Trucks ↑

Direction Distribution Factor ↑

Growth Factor ↑

The diagram illustrates the components of the Design ESALS equation. The equation is $\text{ESAL} = 365 (\text{ADT}) (\text{T}) (\text{T}_f) (\text{D}) (\text{L}) (\text{G})$. The variables are defined as follows:

- ADT**: Average Daily Traffic (two-way)
- T**: Percent Trucks
- T_f**: Truck Load Factor
- D**: Direction Distribution Factor
- L**: Lane Distribution Factor
- G**: Growth Factor

Design ESALS

$$ESAL = 365 (ADT) (T) (T_f) (D) (L) (G)$$

Truck Load Factor

Lane Distribution Factor

Average Daily Truck Traffic

Direction Distribution Factor

Growth Factor

Design ESALS

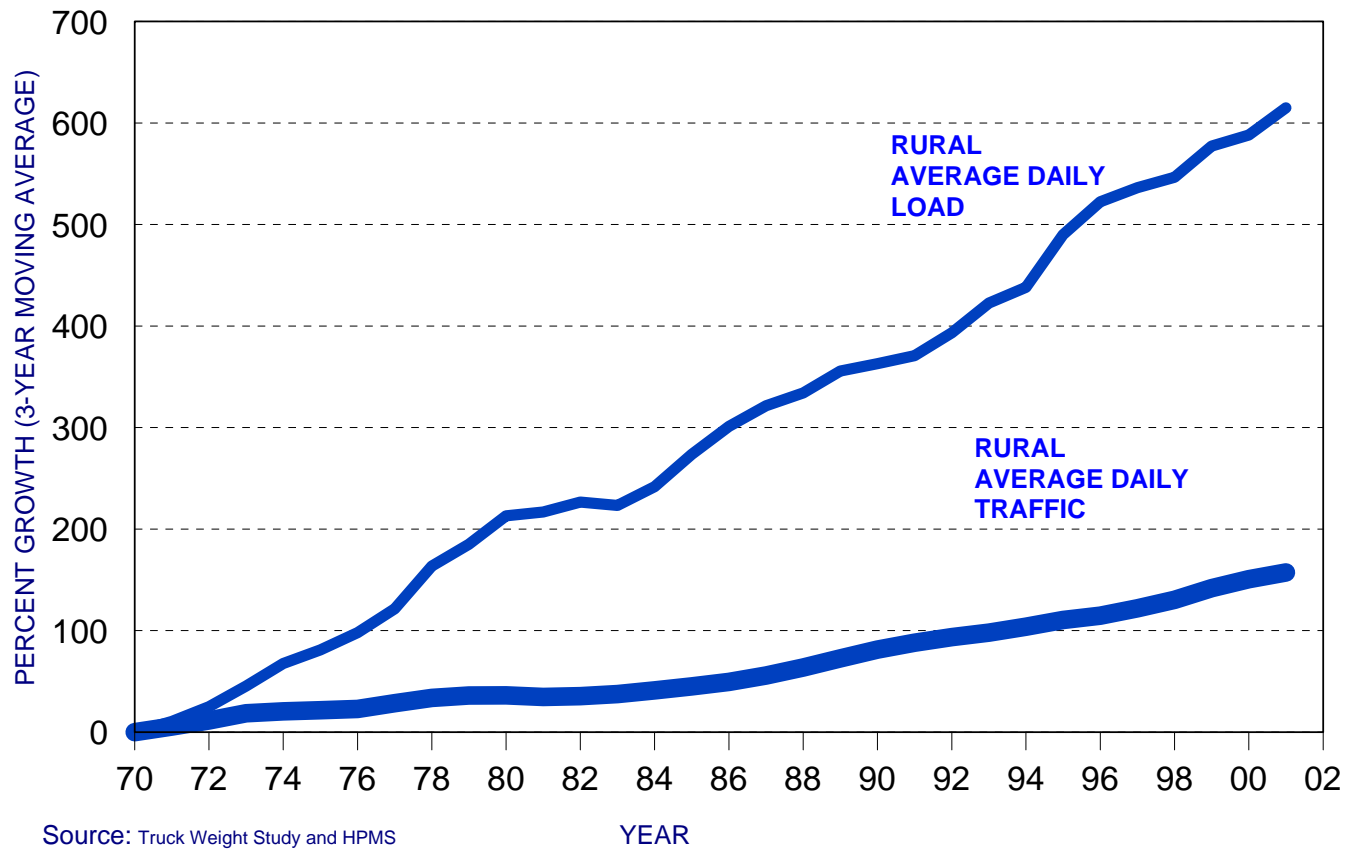
$$\text{ESAL} = 365 (L) (D) \sum_{i=1}^m (N_m) (T_m) (G_m)$$

Diagram illustrating the components of the Design ESALS equation:

- Direction Distribution Factor** (indicated by a downward arrow) points to the variable (D) .
- Truck Load Factor** (indicated by a downward arrow) points to the variable (T_m) .
- Lane Distribution Factor** (indicated by an upward arrow) points to the variable (L) .
- Daily Truck Count (two-way)** (indicated by an upward arrow) points to the variable (N_m) .
- Growth Factor** (indicated by an upward arrow) points to the variable (G_m) .

Traffic Growth

COMPARISON OF GROWTH IN VOLUME AND LOADINGS ON THE INTERSTATE SYSTEM



Growth Factor

$$G = \frac{(1 + g)^n - 1}{g} \quad \text{for } g \neq 0$$

Lane Distribution Factors

| Number of Lanes in Each Direction | Percent of Loads in Design Lane |
|---|------------------------------------|
| 1 | 100 |
| 2 | 80-100 |
| 3 | 60-80 |
| 4 | 50-75 |

Lane Distribution Factor

