Traffic Characterization

Pavement Design Factors

The purpose of the constructed pavement (be it rigid or flexible) is to reduce the high stresses applied on the pavement surface to values low enough not to fail the underlying soil. This is done by providing competent materials of sufficient thickness.

The required thickness depends on the wheel loads applied to the pavement and the support provided by the underlying soil.

Pavement Design Factors

Wheel Loads Applied to Pavement

Magnitude of Wheel Loads

Type of Wheel Loads (Single or Tandem Axles)

Number of Wheel Load Applications

Changes over Time

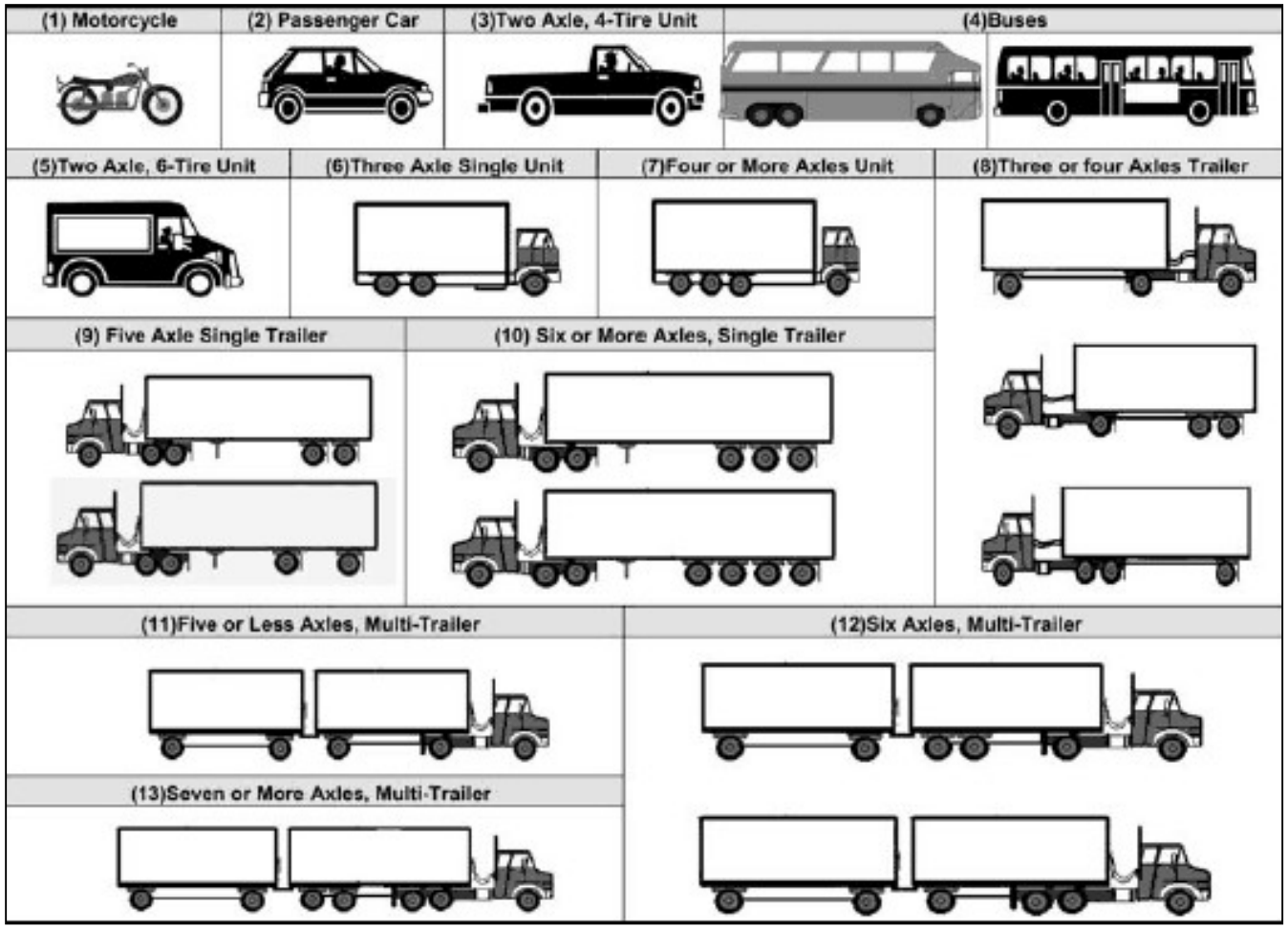
Subgrade Support Provided

Seasonal Changes in Subgrade Support

Pavement Design Factors

Pavements generally don't fail due to a single very high wheel load. Instead, they wear out over time, much like a paperclip that is bent back and forth until it breaks. The rate at which they wear out depends on the number, type and magnitude of the axle loads applied to the pavement. Light vehicles like cars do very little damage while tractor trailers, with multiple axles and high wheel loads, do a lot of damage over time.

FHWA Vehicle Classes



Pavement Design Factors

Since there are so many different types of vehicle using the road, we need a way to reduce the stream of vehicles to a single number that represent the total amount of damage that will be done to the pavement over its lifetime.

This is done using damage factors that convert the damage done by each passage of a given vehicle into an equivalent number of passages of some “standard” vehicle.

Damage Factors

If the only vehicle on the road was a Mazda Miata and we could drive that Miata up and down the road until the pavement failed, we could then calculate the amount of pavement life consumed each time a Miata drives down the road.

If the only vehicle on the road was a Ford Excursion, we could repeat the exercise and calculate the amount of pavement life consumed each time an Excursion drives down the road.

Damage Factors

If we then postulate some “standard” vehicle and we could determine how many passages of that standard vehicle are needed to fail the pavement, we could calculate an equivalency factor to turn each passage of a Miata or an Excursion into an equivalent number of passages of the standard vehicle.

Now we can design the pavement to withstand some equivalent number of passages of the standard vehicle.

Damage Factors

Mazda Miata

Curb weight = 2300 lb

Ford Excursion

Curb weight = 6300 lb

$$d_M = \frac{1}{N_M}$$

$$d_F = \frac{1}{N_F}$$

Damage Factors

Mazda Miata

Curb weight = 2300 lb

$$d_M = \frac{1}{N_M} = \frac{1}{100{,}000{,}000\ passages}$$

Damage Factors

Ford Excursion

Curb weight = 6300 lb

$$d_E = \frac{1}{N_E} = \frac{1}{2{,}000{,}000\ passages}$$

“Standard” Vehicle

Curb weight = 4300 lb

$$d_S = \frac{1}{N_S} = \frac{1}{8{,}000{,}000\ passages}$$

Equivalency Factors

Mazda Miata

Curb weight = 2300 lb

$$F_M = \frac{d_M}{d_S} = \frac{8,000,000}{100,000,000} = 0.08$$

Equivalency Factors

Ford Excursion

Curb weight = 6300 lb

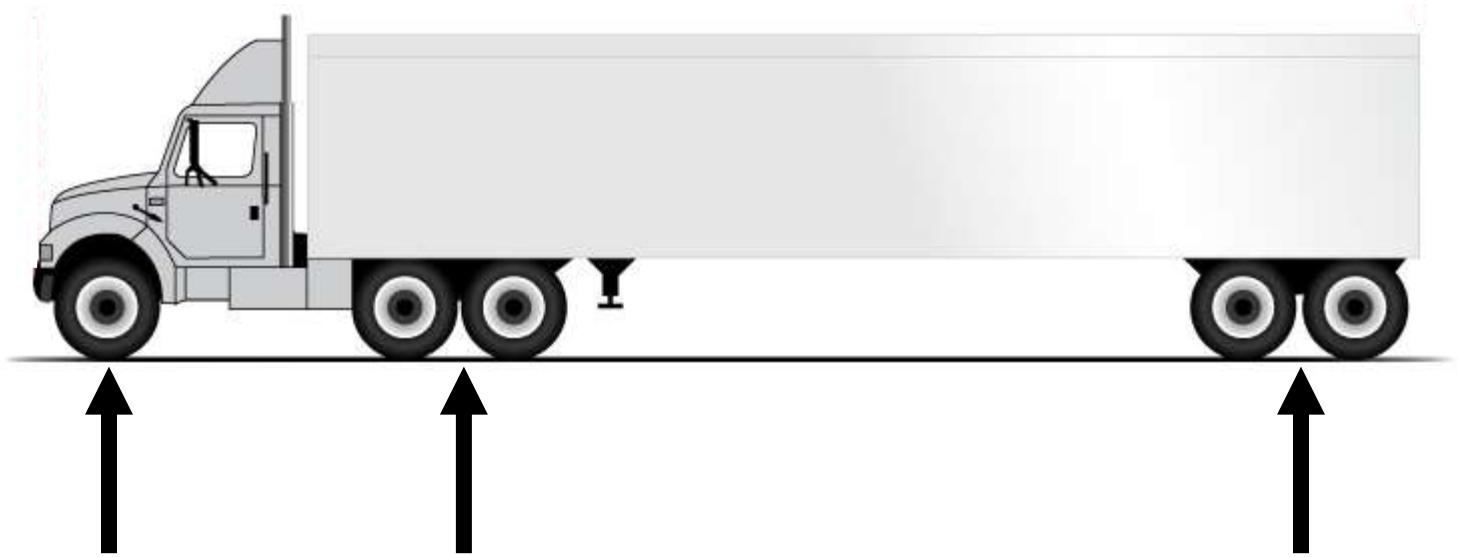
$$F_E = \frac{d_E}{d_S} = \frac{8,000,000}{2,000,000} = 4.0$$

Equivalency Factors

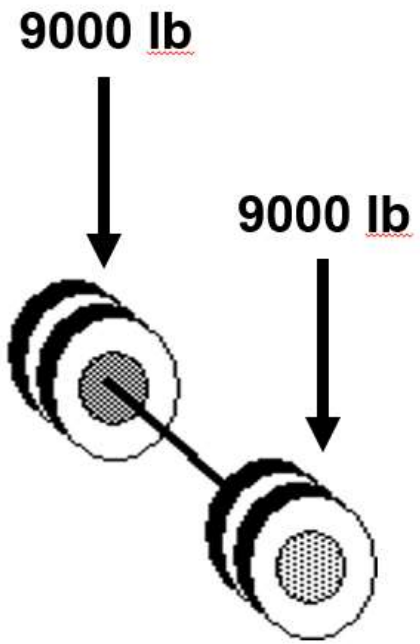
Rather than use a standard vehicle we actually use a standard axle consisting of dual wheels, each carrying 9000 lb of load.

We then look at all of the vehicles on the road one axle at a time and convert each vehicle into a number of equivalent standard axle loads (ESALs) using an equivalent axle load factor (EALF).

Typical Axle Loads



“Standard” Axle



Single Axle, Dual Wheels

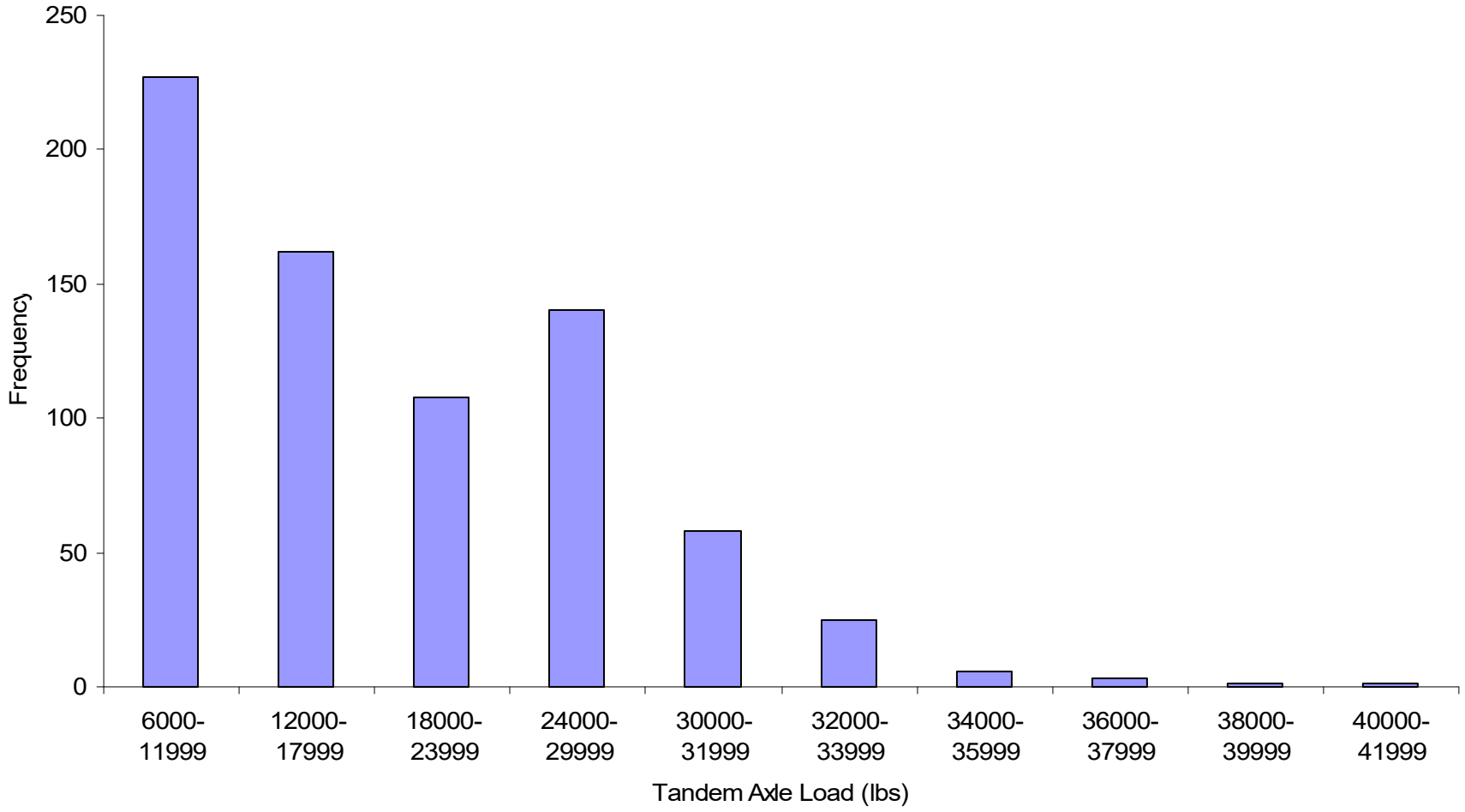
AASHTO Equivalency Factors

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.							

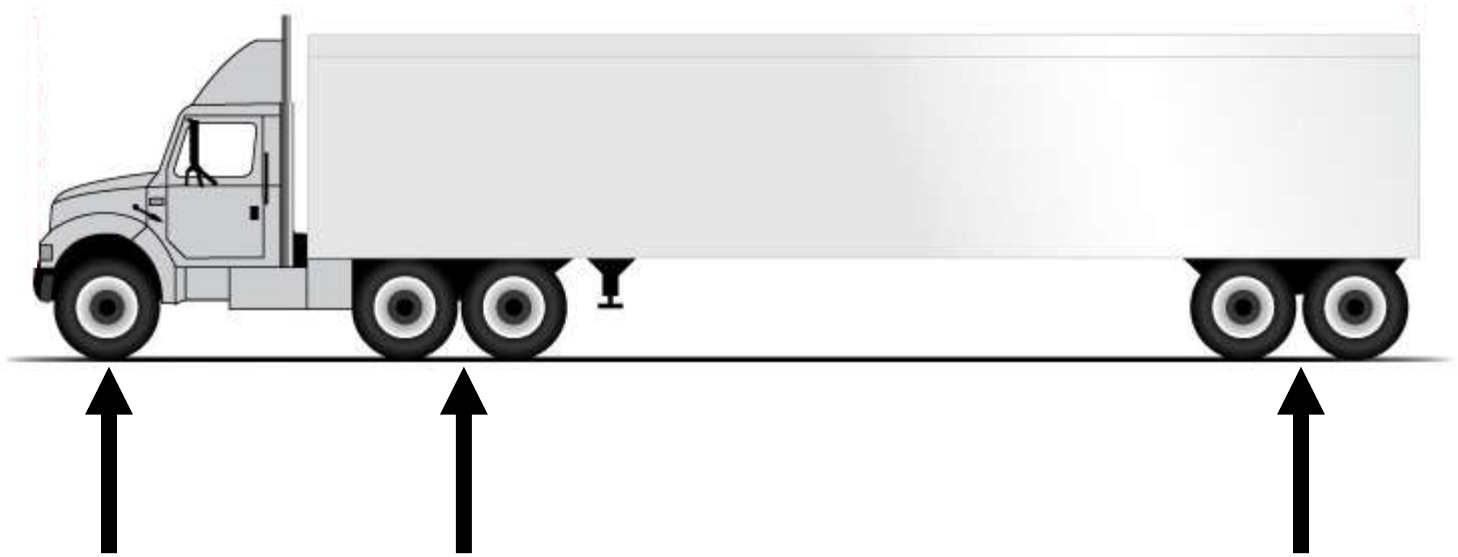
Source: NCEES *FE Supplied Reference Handbook*

Weigh Station

Axle Load Histogram



Equivalent Single Axle Loads



ESAL = ??

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

Source: NCEES *FE Supplied Reference Handbook*

FHWA Equivalency Factors

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