Rigid Pavement Design

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a) Portland Cement Association (PCA) Method
b) Corps of Engineers Method
c) Federal Aviation Administration (FAA) method

Principles of Rigid Pavement Design

- Based on Westergaard analysis of edge loaded slabs
- Determine k value for rigid pavement
- Concrete flexural strength
- Gross weight of design aircraft
- Annual departures of design aircraft

FAA: Rigid Pavement Design

- Concrete flexural strength: 600-650 psi.
- Subbase:
  - Minimum thickness = 4 in.
  - Item P-208 – Aggregate Base Course
  - Item P-209 – Crushed Aggregate Base Course
  - Item P-211 – Lime Rock Base Course
  - Item P-304 – Cement Treated Base Course
  - Item P-306 – Econocrete Subbase Course
  - Item P-401 – Plant Mix Bituminous Pavements

FAA: Rigid Pavement Design

- Conditions where no subbase is required

Soil Classification	Good Drainage		Poor Drainage	
	No Frost	Frost	No Frost	Frost
GW	X	X	X	X
GP	X	X	X	
GM	X			
GC	X			
SW	X			

Note: X indicates conditions where no subbase is required.

- Item P-304 – Cement Treated Base Course
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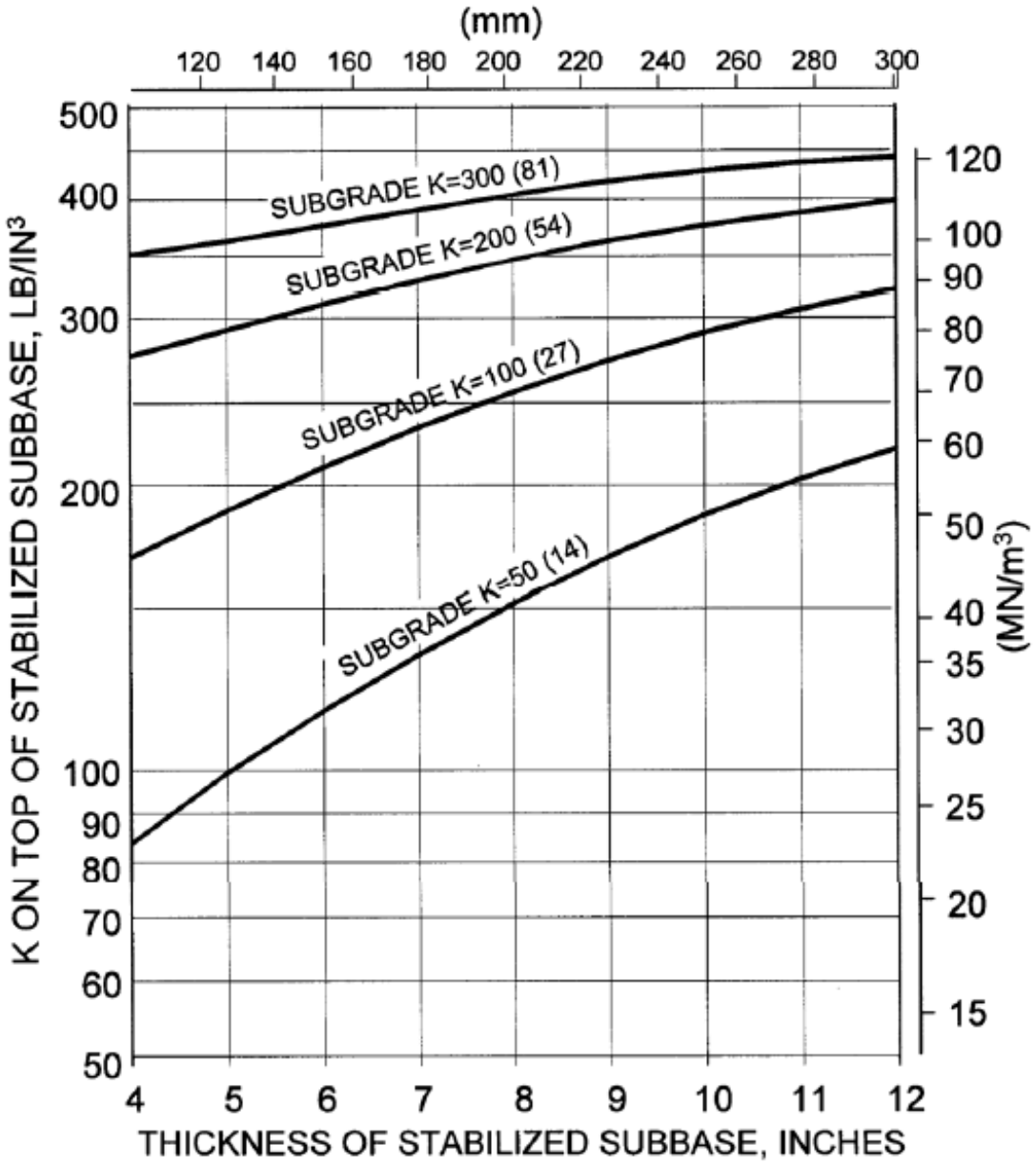
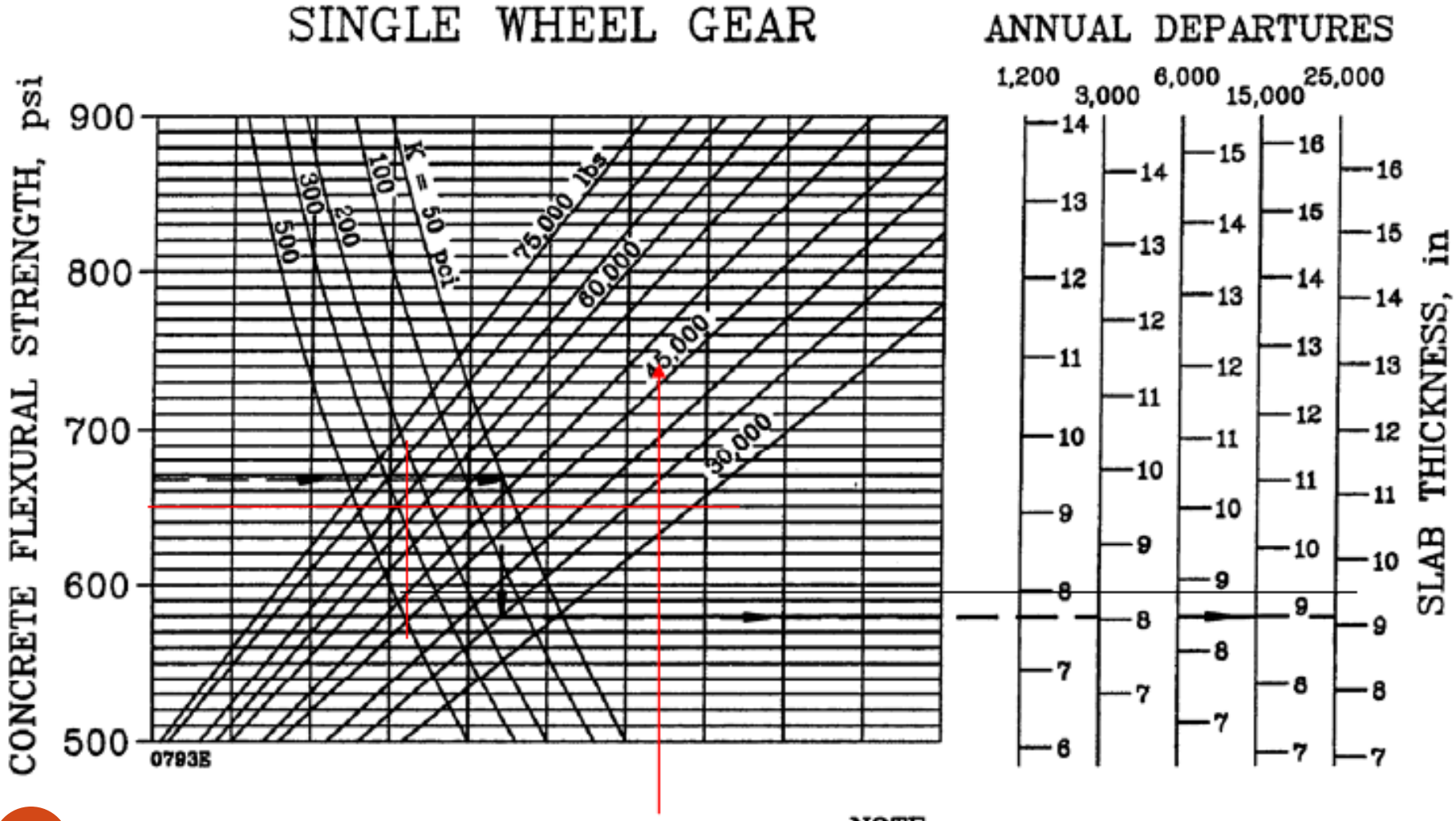
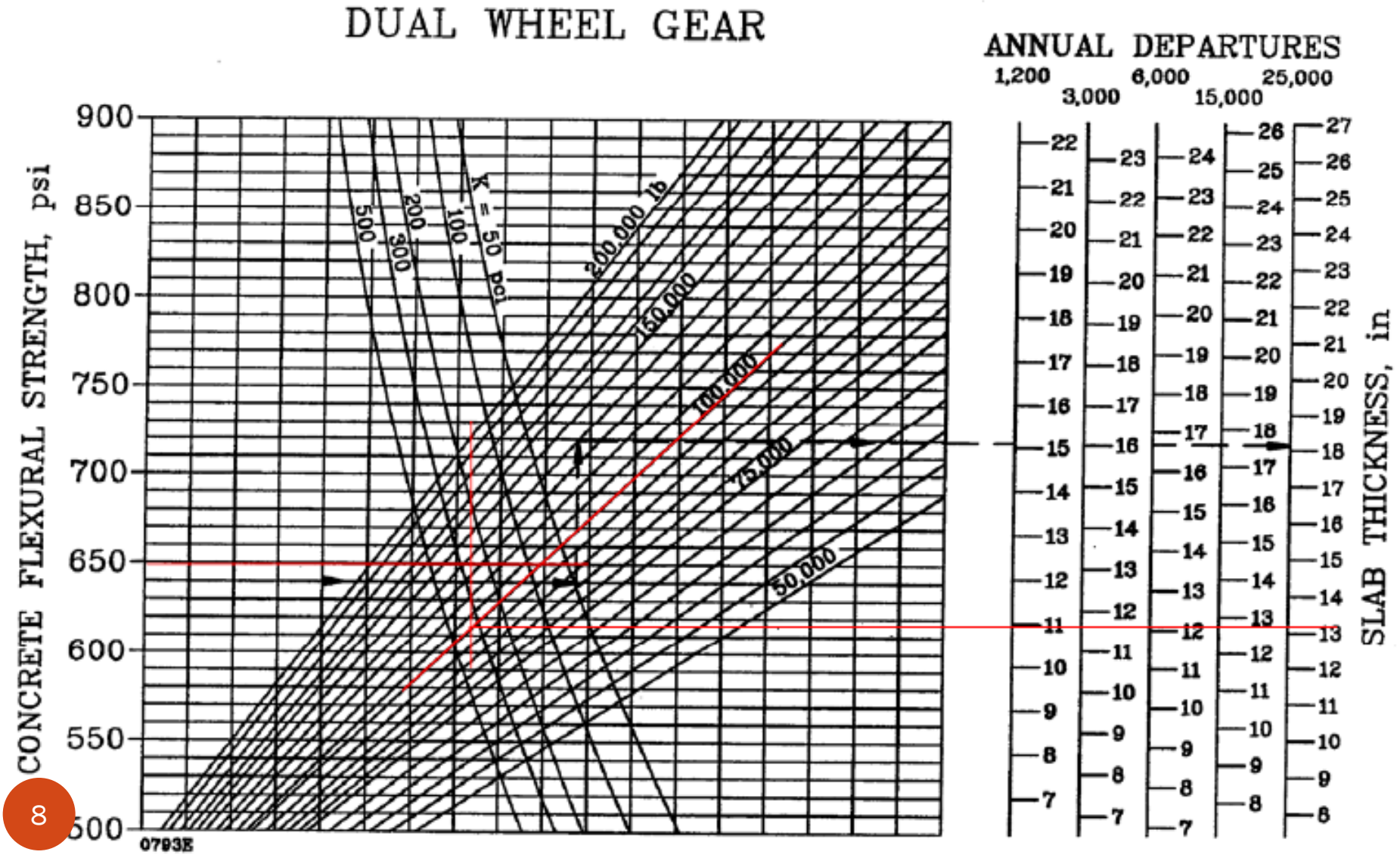


Effect of stabilized subbase on subgrade modulus

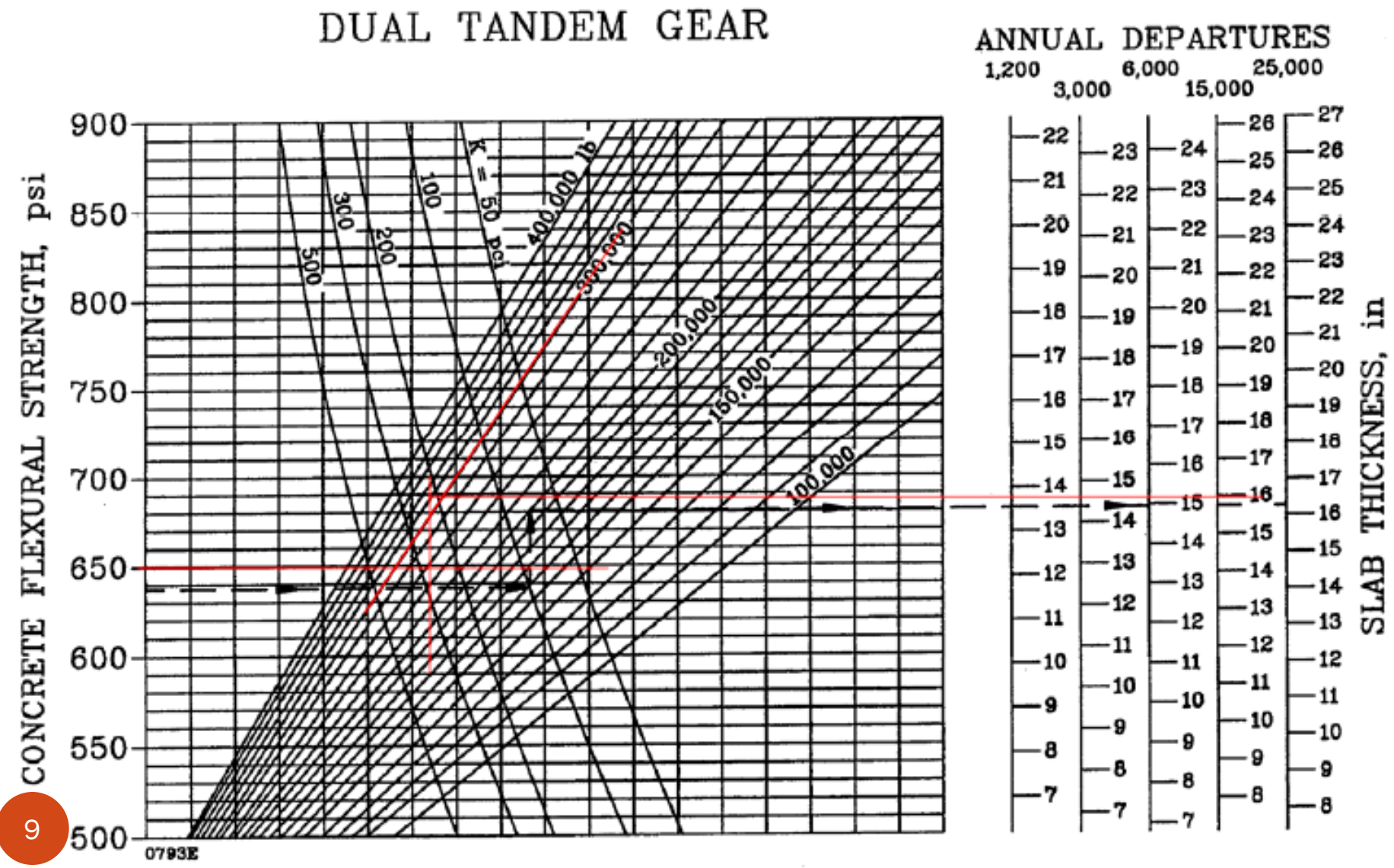
Design Curves



Design Curves



Design Curves



Critical and Noncritical Areas

- Total critical pavement thickness = T
- Non critical pavement thickness = 0.9T (concrete slab thickness)
- For variable thickness section of thinned edge and transition section, the reduction applies to concrete slab thickness
- The change in thickness for transitions should be accomplished over an entire slab length or width

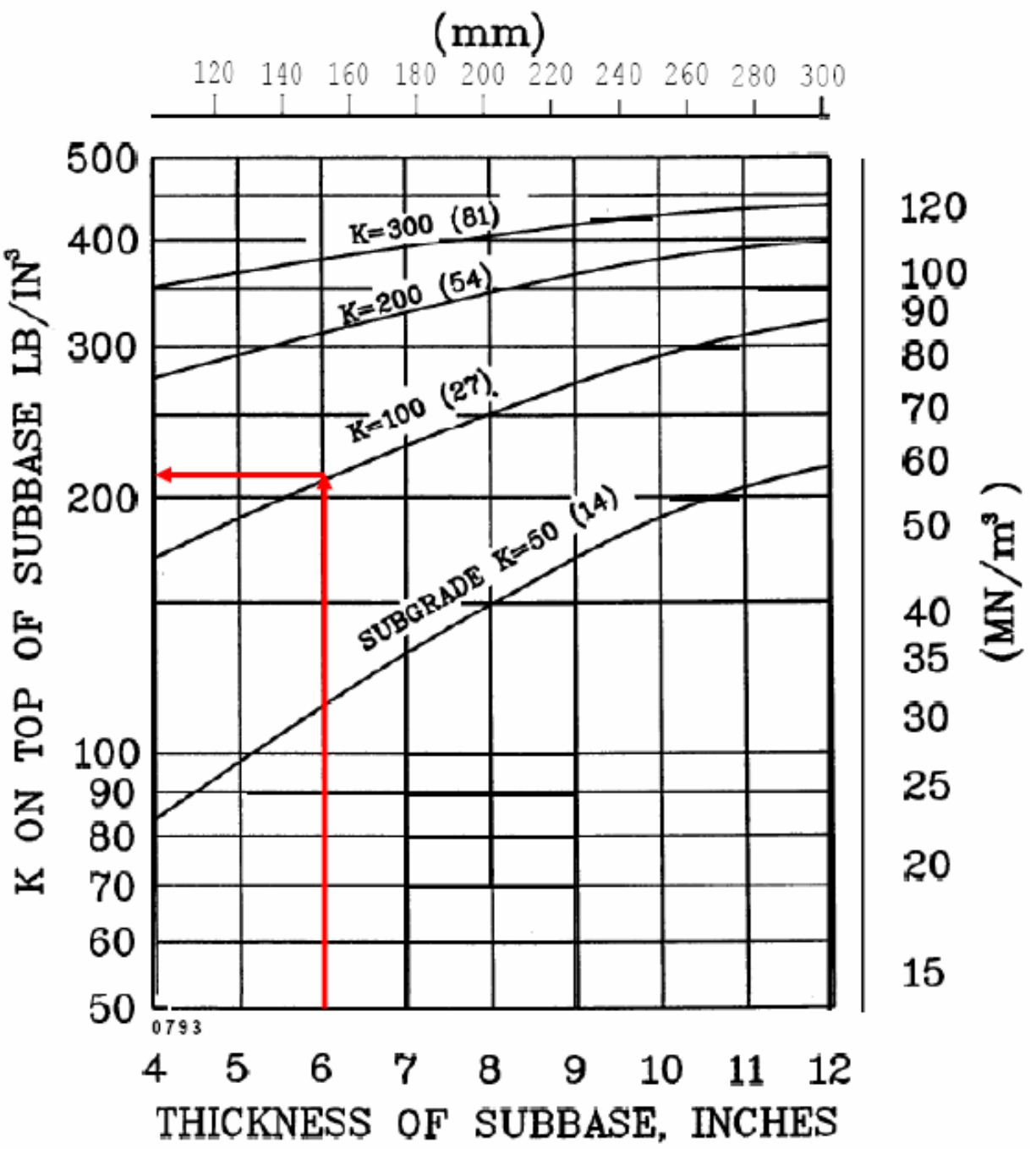
Design Example

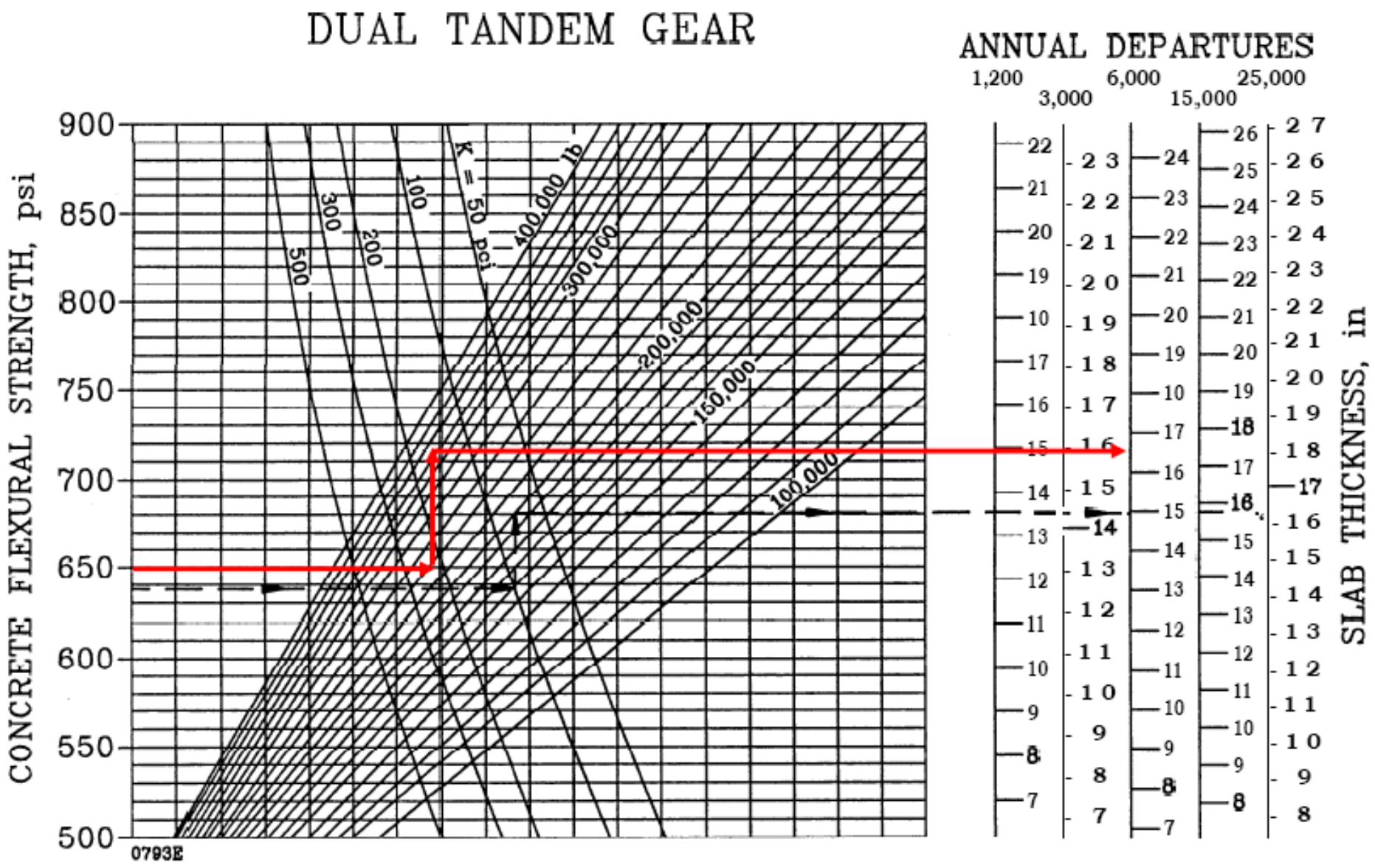
- Rigid pavement is to be designed for dual tandem aircraft
- Gross weight = 350,000 lbs
- Annual equivalent departures of design aircraft = 6,000 (include 1,200 annual departures of B-747 weighing 780,000 lbs gross weight) → *require stabilized subbase*
- Subgrade k = 200 pci, poor drainage and frost penetration = 18 in.

Design Example

- Primary runway, 100% frost protection
- Subgrade soil is CL
- Concrete flexural strength = 650 psi
- Several thickness of subbase thickness should be tried to get the most economical section
- Assume stabilized subbase P-304 will be used
- Try subbase thickness of 6 in.

Find K on top of subbase = 210 pci.



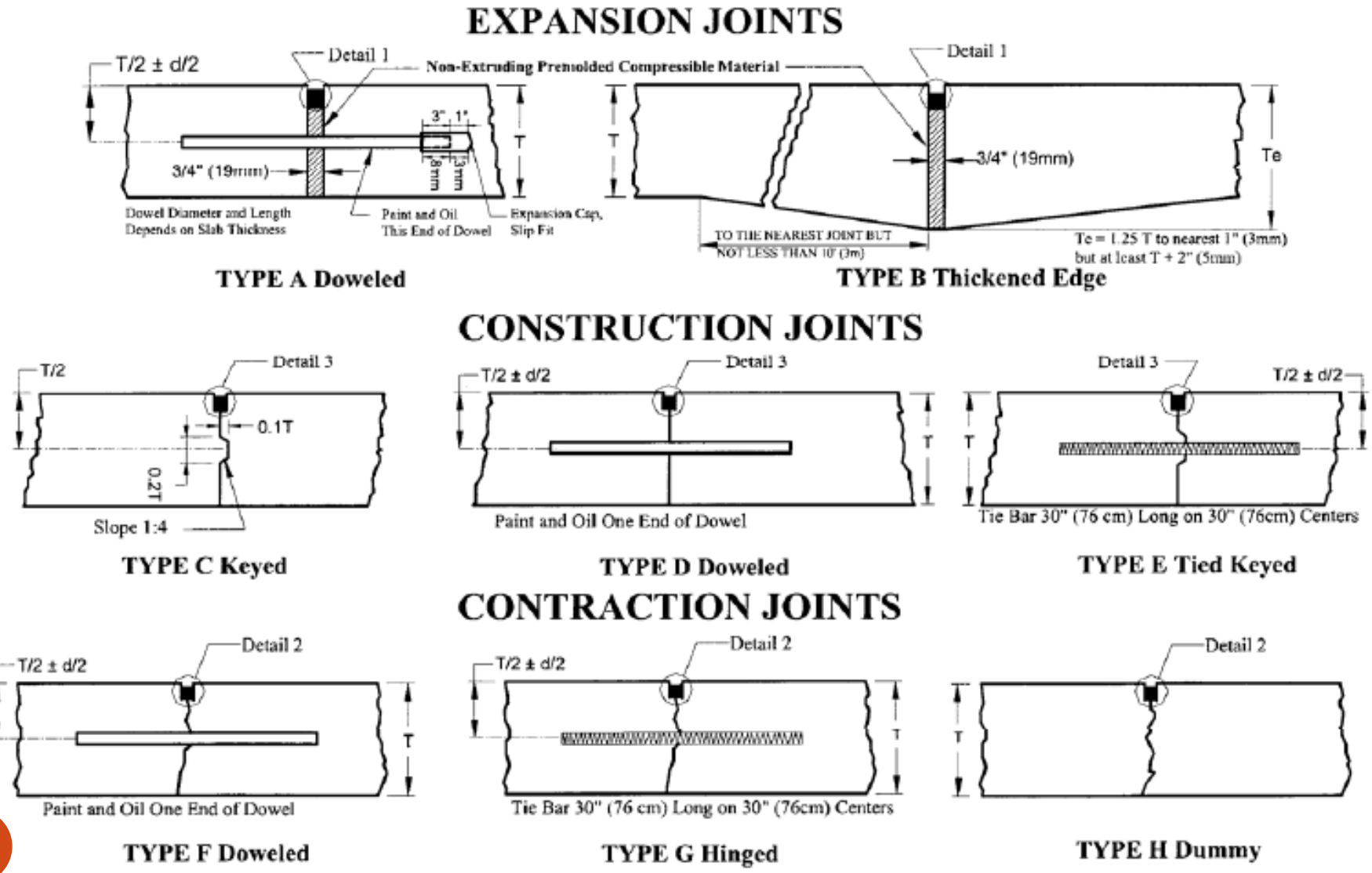


Concrete pavement thickness = 16.6 in.

Slab Thickness

- Concrete slab thcikness = 17 in. (round up)
- Slab 17 + subbase 6 = 23 in. > 18 in. frost depth

Rigid Pavement Joint Types and Details



Recommended Maximum Joint Spacings Rigid Pavement without Stabilized Subbase

Slab Thickness		Transverse		Longitudinal	
Inches	Millimeters	Feet	Meters	Feet	Meters
6	150	12.5	3.8	12.5	3.8
7-9	175-230	15	4.6	15	4.6
9-12	230-305	20	6.1	20	6.1
> 12	>305	25	7.6	25	7.6

Dimensions and Spacing of Steel Dowels

Thickness of Slab	Diameter	Length	Spacing
6-7 in (150-180 mm)	3/4 in (20 mm)	18 in (460 mm)	12 in (305 mm)
8-12 in (210-305 mm)	1 in (25 mm)	19 in (480 mm)	12 in (305 mm)
13-16 in (330-405 mm)	1 1/4 in[1] (30 mm)	20 in (510 mm)	15 in (380 mm)
17-20 in (430-510 mm)	1 1/2 in[1] (40 mm)	20 in (510 mm)	18 in (460 m)
21-24 in (535-610 mm)	2 in[1] (50 mm)	24 in (610 mm)	18 in (460 mm)

[1]Dowels noted may be solid bar or high-strength pipe. High-strength pipe dowels must be plugged on each end with a tight-fitting plastic cap or with bituminous or mortar mix.

Amount of Reinforcement

$$A_s = 3.7\frac{L^2 t}{f_s}$$

A_s= area of steel per foot of width or length (square inches)

L = length or width of slab (feet)

t = thickness of slab (inches)

f_s= allowable tensile stress in steel (psi.)

Minimum percentage of steel reinforcement = 0.05% to the area of concrete per unit length or width

Allowable Strengths of Various Grades of Reinforcement Steel

Allowable

ASTM Designation	Type & Grade of Steel	Yield Strength psi (MN/m^2)	FS psi (MN/m^2)
A 615	Deformed Billet Steel, Grade 40	40,000 (300)	27,000 (200)
A 616	Deformed Rail Steel, Grade 50	50,000 (370)	33,000 (240)
A 616	Deformed Rail Steel, Grade 60	60,000 (440)	40,000 (300)
A 615	Deformed Billet Steel, Grade 60	60,000 (440)	40,000 (300)
A 185	Cold Drawn Welded Steel Wire Fabric	65,000 (480)	43,000 (320)
A 497	Cold Drawn Welded Deformed Steel Wire	70,000 (520)	47,000 (350)

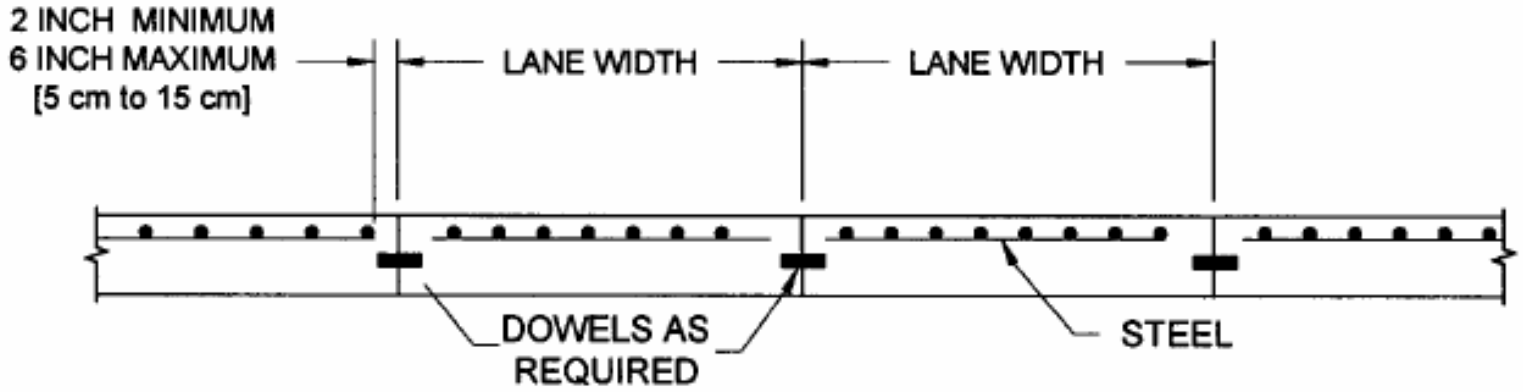
Dimensions and Unit Weights of Deformed Steel Reinforcing Bars

Number	NOMINAL DIMENSIONS Diameter in. (mm)	Area in.^{2} (cm^2)	Perimeter in. (cm)	Unit Weight lbs./ft. (kg/m)
3	0.375 (9.5)	0.11 (0.71)	1.178 (3.0)	0.376 (0.56)
4	0.500 (12.7)	0.20 (1.29)	1.571 (4.0)	0.668 (1.00)
5	0.625 (15.9)	0.31 (2.00)	1.963 (5.0)	1.043 (1.57)
6	0.750 (19.1)	0.44 (2.84)	2.356 (6.0)	1.502 (2.26)
7	0.875 (22.2)	0.60 (3.86)	2.749 (7.0)	2.044 (3.07)

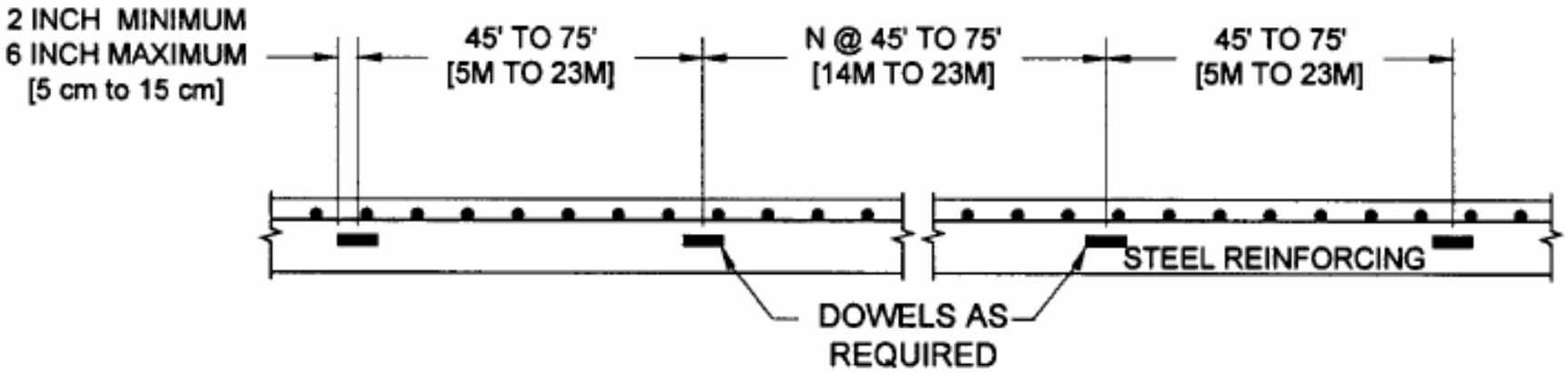
Sectional Areas of Welded Fabric

Wire Size Smooth	Number Deformed	Nominal Diameter Inches	Nominal Weight lbs./lin.ft.	Center-to-Center Spacing				
				4"	6"	8"	10"	12"
W31	D31	0.628	1.054	.93	.62	.465	.372	.31
W30	D30	0.618	1.020	.90	.60	.45	.36	.30
W28	D28	0.597	.952	.84	.56	.42	.336	.28
W26	D26	0.575	.934	.78	.52	.39	.312	.26
W24	D24	0.553	.816	.72	.48	.36	.288	.24
W22	D22	0.529	.748	.66	.44	.33	.264	.22
W20	D20	0.504	.680	.60	.40	.30	.24	.20
W18	D18	0.478	.612	.54	.36	.27	.216	.18
W16	D16	0.451	.544	.48	.32	.24	.192	.16
W14	D14	0.422	.476	.42	.28	.21	.168	.14
W12	D12	0.390	.408	.36	.24	.18	.144	.12
W11	D11	0.374	.374	.33	.22	.165	.132	.11
W10.5		0.366	.357	.315	.21	.157	.126	.105
W10	D10	0.356	.340	.30	.20	.15	.12	.10
W9.5		0.348	.323	.285	.19	.142	.114	.095
W9	D9	0.338	.306	.27	.18	.135	.108	.09
W8.5		0.329	.289	.255	.17	.127	.102	.085
W8	D8	0.319	.272	.24	.16	.12	.096	.08
W7.5		0.309	.255	.225	.15	.112	.09	.075
W7	D7	0.298	.238	.21	.14	.105	.084	.07
W6.5		0.288	.221	.195	.13	.097	.078	.065
W6	D6	0.276	.204	.18	.12	.09	.072	.06
W5.5		0.264	.187	.165	.11	.082	.066	.055
W5	D5	0.252	.170	.15	.10	.075	.06	.05
W4.5		0.240	.153	.135	.09	.067	.054	.045
W4	D4	0.225	.136	.12	.08	.06	.048	.04

Jointing of Reinforced Rigid Pavement



TRANSVERSE CROSS SECTION OF PAVING LANES



LONGITUDINAL CROSS SECTION