Thickness Design of Rigid Pavement:

Design methods:

1) PCA method (Portland Cement Association)

2) AASHO (AASHTO) guide method

1) ***PCA method***: depends on fatigue analysis under repeated loading.

h = f (axle type, axle load magnitude, No. of repetitions, M. R. (f_r), & K)

where:

h = thickness of concrete layer

Design steps:

a) Analysis of traffic:

$N_{act.}$: Actual No. of repetitions in 40-years period for each axle load.

Axles ≥ 16 kips – Single (المحاور أقل من 16 ومفردة تهمل)

Axles ≥ 30 kips – Tandem (المحاور أقل من 30 ومزدوجة تهمل)

$$N_{act.} = T * A * 40 * 365$$

Where:

T = Future truck per day per direction

A = No. of axles per truck for certain axle load

b) Correction for impact:

Static axle load * 1.2 = corrected (dynamic) axle load

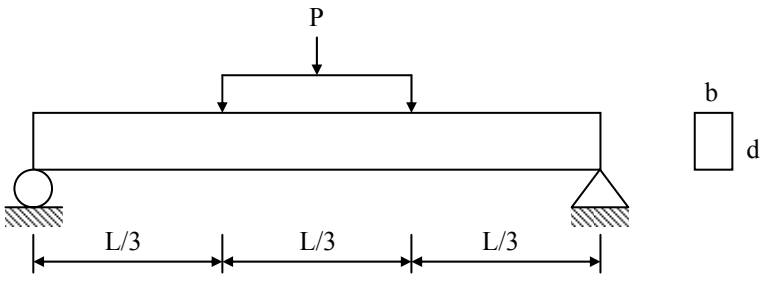
c) M. R. (f_r): Modulus of rupture (for third-point loading) (psi)

$$\sigma = \frac{M.C}{I}$$

Where:

$$M = \frac{P.L}{6},\ C = \frac{d}{2},\ I = \frac{b.d^3}{12}$$

$$\therefore\ M.R. = \frac{P.L}{b.d^2}$$



$$M.R. = 8 - 10\sqrt{f_c}$$

$$= 600 - 750 \text{ psi}$$

Where: f_c = Compression strength of concrete (psi)

d) K: Modulus of subgrade reaction

e) S: Actual load stress in pavement

Determine form design charts from either single or tandem axle, depend on:

- Corrected axle load
- K – value
- Suggested thickness of concrete layer "d"

f) SR: Stress ratio

$$SR = \frac{S}{M.R.}, \text{ for each axle load}$$

g) $N_{all.}$: Allowable No. of repetitions of each axle load to account for fatigue in concrete pavement (depend on stress ratio SR)

Note: Unlimited repetitions for SR = 0.5 or less → ∞ vehicles

h) F: Fatigue percentage

$$F = \frac{N_{act.}}{N_{all.}} * 100\%, \text{ for each axle load}$$

i) Σ F < 100%, for correct assumption of "d" value

إذا كانت ($\Sigma F \geq 100\%$) فيجب تكبير "d" وإعادة التصميم.

إذا كانت ($\Sigma F \leq 85\%$) فتبقى "d"،

أما إذا كانت أقل من (85%) فالتصميم غير اقتصادي أي نقلل "d" بمقدار ("0.5-1) وإعادة التصميم.

Design monographs and tables: Yoder (Fig. 17.2, 17.3, P.604, 605), (Table 17.1, P.603)

Ex.:

T = 60 trucks/day/dir, K = 150 psi, & M. R. = 650 psi

Axle type	Axle load (kips)	A' (No. of axles/100 trucks)
Tandem	45	0.1
	43	0.1
	41	0.1
	39	1.0
	37	0.9
	35	1.4
	33	1.8
	31	9.4
Single	21	3.2
	19	5.4
	17	6.1

Find concrete layer thickness "d" using P.C.A. method?

Sol.:

$N_{act.} = 60*(A'/100)*40*365$ …(1)

Corrected axle load = 1.2*axle load …(2)

$SR = \frac{S}{650}$ …(3)

$F = \frac{N_{act.}}{N_{all.}} * 100\%$ …(4)

Assume d = 7"

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Axle type	Axle load	A' (No. of axles/ 100 trucks)	$N_{act.}$	Corrected axle load	S	SR	$N_{all.}$	F (%)
			(3)+eq.(1)	(2)+eq.(2)	Graph+(5)+K+d	(6)+eq.(3)	(7)+table	(4)+(8)+eq.(4)
Tandem	45	0.1	876	54	435	0.67	4500	19
	43	0.1	876	51.6	415	0.64	11000	8
	41	0.1	876	49.2	410	0.63	14000	6
	39	1.0	8760	46.8	390	0.60	32000	27
	37	0.9	7884	44.4	375	0.58	57000	14
	35	1.4	12250	42.8	350	0.54	180000	7
	33	1.8	15800	39.6	325	0.50	∞	0
	31	9.4	82400	37.6	310	0.48	∞	0
Single	21	3.2	28100	25.2	350	0.54	180000	15
	19	5.4	47400	22.8	325	0.50	∞	0
	17	6.1	53500	20.1	290	0.45	∞	0
							ΣF	96%

ΣF(%) = 96% < 100%

∴ d = 7" OK