CONSULTING ENGINEERING SERVICES (I) PVT.LTD.

DPR of Roads in Nanded Waghala City- Road NO.7 & 8 **DESIGN OF PLAIN JOINTED RIGID PAVEMENT** *(FOR THICKNESS = 30cm)* *2 of 2*

STEP 6: CALCULATION OF LOAD STRESS IN CRITICAL REGION (EDGE)

(WESTERGAARD EQUATION)

$\sigma = 0.529\,(P/h^2)\,(1+0.54\mu)\,[\,4\,\mathrm{Log}_{10}\,(l/b) + \mathrm{Log}_{10} b - 0.4048]$

where

σ = **Load stress in edge region (Kg/cm^2)**

P = design wheel load
= half of the single axle load
= one fourth of the tandem axle load

h = pavement thickness in cm.
μ = poissons ratio for concrete
E = moduls of elasticity of concrete
k = modulus of subgrade reaction
l = radius of relative stiffness, cm.
a = radius of load contact area, assumed circular, cm.

$$= \left[\frac{0.8521\,P_d}{q\,\pi} + S\left(\frac{P_d}{\pi\,(0.5227\,q)}\right)^{0.5}\right]^{0.5}$$ for single axle dual wheels

b = radius of equivalent distribution of pressure
= **a** for a/h > 1.724
= **$(1.6\,a^2 + h^2)^{1/2} - 0.675\,h$** for a/h < 1.724

P_d = load on one tyre
S = c/c distance of two tyres in dual wheel assembly **=31cm**
q = tyre pressure, 8 Kg/cm^2

STRESS RATIO, SR = (EdgeStress **'σ'** calculated as above) / (Flexural Strength of Concrete)

Fatigue Life = N = Unlimited for SR < 0.45

$$N = \left[\frac{4.2577}{(SR) - 0.4325}\right]^{3.268}$$ **when 0.45 < SR < 0.55**

$$\mathrm{Log}_{10} N = \frac{0.9718 - SR}{0.0828}$$ **when SR > 0.55**

STEP 7: CALCULATION OF LOAD STRESS IN CRITICAL REGION (EDGE)

Sl. No.	Axle Load (AL) Tonnes	(AL) x (LSF)	Wheel Load (P) (Kg)	a	b	Edge Stress (σ) from chart (Kg/cm^2)	Total* Stress (Kg/cm^2)	Check**	Stress Ratio (SR)	Expected Repetitions	Fatigue Life (N)	Fatigue Life Consumed (X) / (XI)
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)	(XI)	(XII)
Single Axle												
1	20	24	12000	24.025	22.453	21.000	46.83	UNSAFE	0.60	0	146507	0.00
2	18	21.6	10800	23.188	21.706	19.000	44.83	UNSAFE	0.54	0	1225917	0.00
3	16	19.2	9600	22.295	20.924	17.000	42.83	UNSAFE	0.49	0	INFINITE	0.00
4	14	16.8	8400	21.334	20.101	15.500	41.33	OK	0.44	26,804	INFINITE	0.00
5	12	14.4	7200	20.288	19.228	13.000	38.83	OK	0.38	53,789	INFINITE	0.00
6	10	12	6000	19.132	18.294	11.500	37.33	OK	0.32	204,290	INFINITE	0.00
7	<8	9.6	4800	17.826	17.279	9.000	34.83	OK	0.26	1,526,201	INFINITE	0.00
Tandem Axle												0.00
8	36	43.2	10800	23.188	21.706	16.000	41.83	OK	0.54	0	146,507	0.00
9	32	38.4	9600	22.295	20.924	14.000	39.83	OK	0.49	0	1,225,917	0.00
10	28	33.6	8400	21.334	20.101	12.500	38.33	OK	0.44	0	INFINITE	0.00
11	24	28.8	7200	20.288	19.228	11.500	37.33	OK	0.38	0	INFINITE	0.00
12	20	24	6000	19.132	18.294	9.500	35.33	OK	0.32	0	INFINITE	0.00
13	16	19.2	4800	17.826	17.279	8.000	33.83	OK	0.26	278,545	INFINITE	0.00
14	<16	19.2	4800	17.826	17.279	6.250	32.08	OK	0.26	1,532,540	INFINITE	0.00
									Factor of Safety <1 hence safe			**0.00**
Overall Average Distribution							**5.98**	OK	0.05	**3,622,169**	**INFINITE**	**0.00**

*** = Total Stress = Temperature Stress + Edge Stress.**
**** = Check whether Total Stress is < 43 Kg/cm^2 (Flexural Strength of Concrete)**

STEP 8: CALCULATION OF CORNER STRESS

Check For Corner Stress

98 Percentile Axle Load	=	8 Tonnes	
98 Percentile Wheel Load	=	4000 Kg	
Radius of load contact area (a	=	17.826 Cm	
Radius of Relative Stiffness (	=	84.11 Cm	
Depth of Slab	=	30 Cm	
Corner Stress	**=**	**11.1575 kg/Cm^2**	**<44.27**
		therefore	**OK**

98th PERCENTILE LOAD CALCULATION

Typical Axle Load Distribution

Single Axle Loads		Equivalent Single Axle Load	Tandem Axle Loads		Equivalent Single Axle Load
Axle Load	Distribution		Axle Load	Distribution	
19-21	0.00%	20T	34-38	0.00%	18T
17-19	0.00%	18T	30-34	0.00%	16T
15-17	0.00%	16T	26-30	0.00%	14T
13-15	1.48%	14T	22-26	0.00%	12T
11-13	2.97%	12T	18-22	0.00%	10T
9-11	11.28%	10T	14-18	15.38%	8T
<9	84.27%	8T	<14	84.62%	6T

Distribution on Equivalent Single Axle Load

ESAL	Distribution	Percentile			
20T	0.00%	200.00%	say=200	NA	
18T	0.00%	200.00%	say=200	NA	
16T	0.00%	200.00%	say=200	NA	
14T	1.48%	200.00%	say=200	NA	
12T	2.97%	198.52%	say=199	NA	**Therefore, 98 Percentile Axle Load =**
10T	11.28%	195.55%	say=196	NA	
8T	99.65%	184.27%	say=184	NA	
6T	84.62%	84.62%	say=85	8	**8 T**

SUBMITTED BY

For Consultin Engineering Services (I) Pvt.Ltd.

CONSULTING ENGINEERING SERVICES (I) PVT.LTD.

DPR of Roads in Nanded Waghala City- Road NO.7

DESIGN OF PLAIN JOINTED RIGID PAVEMENT *(FOR THICKNESS = 30cm)*

STEP 1: DESIGN DATA

Sr.No.	CRITERIA		VALUE ADOPTED
1	Compessive Strength of Concrete **(F_{ck})**	=	**350 Kg/cm^2 =35 mpa**
2	Flexural Strength of Concrete = **0.7 $\sqrt{F_{ck}}$**	=	**41.41 Kg/cm^2 =4.14 mpa**
3	Elastic Modulus of Concrete **(E)**	=	**300,000** Kg/cm^2 **(Cl.4.7.2- IRC-58)**
4	Poission's Ratio (μ)	=	**0.15 (Cl.4.7.2- IRC-58)**
5	Coefficient of Thermal Expansion of Concrete **(α)**	=	**1.0E-05** /^{o}C **(Cl.4.7.3- IRC-58)**
6	Tyre Pressure **(q)**	=	**8** Kg/cm^2 **(Cl.4.2- IRC-58)**
7	Rate of Increase of Traffic for every 5 year **(r)**	=	**4% 3% 3% 2%**
8	Spacing of Contraction Joints **(L)**	=	**450 Cm**
9	Width of Slab **(B)**	=	**375 Cm**
10	Present Traffic Volume	=	**935 ESAL/Day**
11	Design Life of Pavement	=	**20 Years**
12	Number of Lanes/ Carriageway	=	**2**
13	Dual Carriageway (Y/N)	=	**Y**
14	Type of Subgrade	=	**S** (R for Rocky & S for Soil)
15	If Soil Subgrade, CBR of Subgrade (%)	=	**3**
16	Temperature Differential **(t)**	=	**21 ^{o}C (Table-1- IRC-58)**
17	Load Safety Factor **(LSF)**	=	**1.2 (Cl.4.2- IRC-58)**
18	c/c distance of two tyres in dual wheel assembly, **(S)**	=	**31 cm**

STEP 2: DESIGN TRAFFIC CALCULATION (EQUIVALENT STANDARD AXLE LOADS):-

	Present Traffic	=	267	Commercial Veh.per day.		
	Weighted average of Vehicle Damage Factor	=	3.500	(refer enclosed Traffic Data)		
∴	Equvalent Std.Axles/Day (ESAL) = 3.5X345	=	935			
	Direction Distribution Factor **(D_f)**	=	25%			
	No. of Repetitions per lane:-'=365 x 935 x 0.25 x [(1+0.04)5 - 1]/0.04+365 x 935 x 0.25 x [(1+0.03)5 - 1]/0.03+					
	365 x 935 x 0.25 x [(1+0.03)5 - 1]/0.03+	=	**1811085**	**ESAL**		
	365 x935 x 0.25 x [(1+0.02)5 - 1]/0.02	=	**1.8111**	**MSAL**	(Million std.axles)	

STEP 3: CALCULATIONS FOR MODULUS OF SUBGRADE REACTION "K"

For CBR 3.00 % , K value of DLC of 150 mm Thick- from Table 4,

Therefore K Value of the DLC = **13.8**

STEP 4: CALCULATION OF REPETITIONS OF AXLE LOADS FOR DIFFERENT MAGNITUDES DURING DESIGN LIFE

Typical Axle Load Distribution				Expected Repetitions during the design life			
Single Axle Loads		Tandem Axle Loads		Single Axle Loads		Tandem Axle Loads	
Axle Load, Tonnes	Distribution	Axle Load, Tonnes	Distribution	Axle Load, Tonnes	Expected Repetitions	Axle Load, Tonnes	Expected Repetitions
(I)	(II)	(III)	(IV)	(V)	(VI) = (ESAL) x (II)	(I)	(VI) = (ESAL) x (IV)
19-21	0.00%	34-38	0.00%	20	0	36	0
17-19	0.00%	30-34	0.00%	18	0	32	0
15-17	0.00%	26-30	0.00%	16	0	28	0
13-15	1.48%	22-26	0.00%	14	26,804	24	0
11-13	2.97%	18-22	0.00%	12	53,789	20	0
9-11	11.28%	14-18	15.38%	10	204,290	16	278,545
<9	84.27%	<14	84.62%	<10	1,526,201	<16	1,532,540
Total	100.00%	**Total**	100.00%				

ITERATIONS FOR STRESS CALCULATIONS :-

STEP 5: TEMPERATURE (WARPING) STRESS CALCULATION

$S_{te} = \frac{E \alpha t C}{2}$ =temperature stresses in the edge region, Kg/cm^2

h = Assumed Thickness of PQC Slab= **30 cm.**

$l = \frac{(E h^3)^{1/4}}{(12(1-\mu^2) K)^{1/4}}$ **= radius of relative stiff ness, cm.**

= 84.106 cm

therefore

L/l = 5.350
B/l = 4.459

} rounded largest Value= **5.4**

C = Bradbury's Coefficient, which can be ascertained directly from Bradbury's Chart against values of L/l and B/l (Fig.2 of IRC:58 - 2002)

C = 0.82 For L/l and B/l = 5.4,

S_{te}= 25.830 Kg/cm^2

Bradbury's Coeff (C)

L/I	C
1	0
2	0.04
3	0.175
4	0.44
5	0.72
6	0.92
7	1.03
8	1.077
9	1.08
10	1.075
11	1.05
12	1

K Value for Subgrade

CBR (%)	K
1	0
2	2.10
3	2.80
4	3.50
5	4.20
6	4.50
7	4.80
8	5.03
9	5.27
10	5.50
11	5.64
12	5.78
13	5.92
14	6.06
15	6.20
16	6.34
17	6.48
18	6.62
19	6.76
20	6.90

K Value for DLC

10Cm	15Cm
5.60	9.70
9.70	13.80
13.15	17.30
16.60	20.80
18.70	24.25
20.80	27.70
23.13	32.37
25.47	37.03
27.80	41.70
30.02	41.70
32.24	41.70
34.46	41.70
36.68	41.70
38.90	41.70
38.90	41.70
38.90	41.70
38.90	41.70
38.90	41.70
38.90	41.70

KSUB	KDLC10	KSUB	KDLC15
2.10	5.60	2.10	9.70
2.80	9.70	2.80	13.80
3.50	13.15	3.50	17.30
4.20	16.60	4.20	20.80
4.50	18.70	4.50	24.25
4.80	20.80	4.80	27.70
5.03	23.13	5.03	32.37
5.27	25.47	5.27	37.03
5.50	27.80	5.50	41.70
5.64	30.02	5.64	41.70
5.78	32.24	5.78	41.70
5.92	34.46	5.92	41.70
6.06	36.68	6.06	41.70
6.20	38.90	6.20	41.70
6.34	38.90	6.34	41.70
6.48	38.90	6.48	41.70
6.62	38.90	6.62	41.70
6.76	38.90	6.76	41.70
6.90	38.90	6.90	41.70

Typical Axle Load Distribution

Single Axle Loads		Equivalent Single	Tandem Axle Loads		Equivalent Single
Axle Load	Distribution	Axle Load	Axle Load	Distribution	Axle Load
19-21	0.20%	20T	34-38	0.30%	18T
17-19	0.50%	18T	30-34	0.30%	16T
15-17	5.20%	16T	26-30	0.60%	14T
13-15	11.80%	14T	22-26	1.80%	12T
11-13	22.00%	12T	18-22	1.50%	10T
9-11	23.30%	10T	14-18	0.50%	8T
<9	30.00%	8T	<14	2.00%	6T

Distribution on Equivalent Single Axle Load

ESAL	Distribution				
20T	0.20%	100.00%	100	0	
18T	0.80%	99.80%	100	0	
16T	5.50%	99.00%	99	0	
14T	12.40%	93.50%	94	14	
12T	23.80%	81.10%	81	12	
10T	24.80%	57.30%	57	10	**98 Percentile**
8T	30.50%	32.50%	33	8	**Axle Load**
6T	2.00%	2.00%	2	6	**14**