

DESIGN REPORT

Plain jointed rigid pavement - PQC 300 mm

Designed in accordance with IRC:58-2015 (cumulative fatigue damage method)

Project	-
Client	-
Location	-
Chainage / section	-
Design	IRC 58 example check
Designed by	-
Checked by	-
Adopted PQC thickness	300 mm
Total CFD (BUC + TDC)	$0.282 + 0.253 = 0.535$
Result	SAFE - CFD ≤ 1.0
Date	31 Oct 2026

Contents

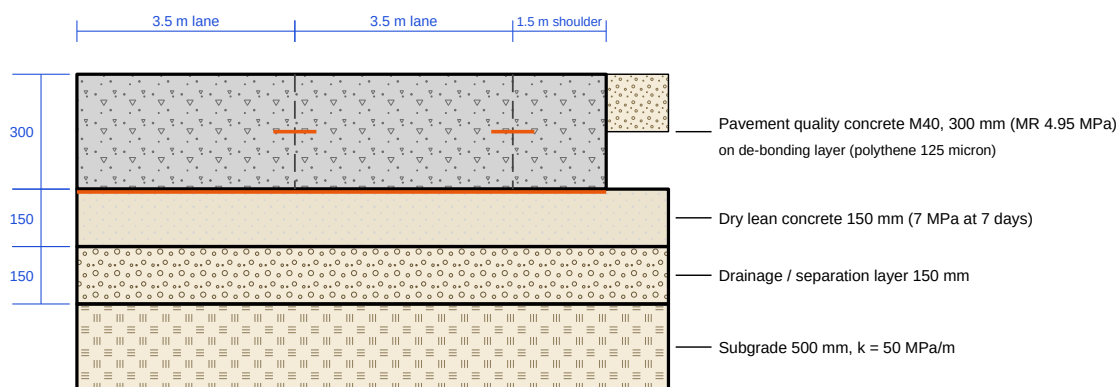
1. Design basis and input data
2. Foundation - effective modulus of subgrade reaction
3. Concrete strength and temperature differential
4. Design traffic and axle load repetitions
5. Bottom-up cracking (BUC) fatigue analysis
6. Top-down cracking (TDC) fatigue analysis
7. Cumulative fatigue damage and slab thickness
8. Joints, dowel bars and tie bars
9. Design summary and recommendations
10. Pavement drawing (A3)

1. Design basis and input data

Plain jointed rigid pavement designed to IRC:58-2015 (Guidelines for the Design of Plain Jointed Rigid Pavements for Highways, 4th revision). The slab thickness is the least thickness for which the sum of the cumulative fatigue damage due to bottom-up cracking (day-time traffic with positive temperature differential) and top-down cracking (night-time traffic with negative temperature differential) does not exceed 1.0 (Cl. 6.3.4). Flexural stresses are from the regression equations of Appendix V and fatigue lives from the PCA equations 5 and 6.

Project	-
Client	-
Location / chainage	-
Road	Four-lane / multi-lane divided highway, 2 lane(s) x 3.5 m
Edge support	Tied concrete shoulder
Transverse joints	contraction joints @ 4.5 m, doweled
Design period	30 years
Concrete	M40; 28-day flexural strength 4.50 MPa; E = 30,000 MPa; $\mu = 0.15$; unit weight 24 kN/m ³
Climatic zone (Table 1)	Zone III - Bihar, Jharkhand, West Bengal, Assam, Eastern Odisha (excluding hilly and coastal areas)
Subbase	Dry lean concrete (DLC) over granular drainage / separation layer

TYPICAL CROSS SECTION (SCHEMATIC)



Layer thicknesses not to scale (vertical exaggeration). Longitudinal joints with tie bars shown dashed.

Fig. 1 Pavement composition (schematic)

2. Foundation - effective modulus of subgrade reaction

Effective k of the foundation (Cl. 5.7, Tables 2 to 4)				OK
Reference	Description	Calculation	Result	
Cl. 5.7.3	k of subgrade (plate load test, 750 mm plate)	given	50.0 MPa/m	
Table 4	Effective k with 150 mm DLC (granular layer below ignored)	k ₁₀₀ = 228.0, k ₁₅₀ = 283.6 -> interpolated	283.6 MPa/m	
Cl. 5.7.4.4	Effective k for design		283.6 MPa/m	

Table 2 of IRC:58-2015 - k-value from soaked CBR

Soaked CBR (%)	2	3	4	5	7	10	15	20	50	100
k (MPa/m)	21	28	35	42	48	55	62	69	140	220

3. Concrete strength and temperature differential

Concrete, temperature and slab stiffness				OK
Reference	Description	Calculation	Result	
Cl. 5.8.1	28-day flexural strength	given	4.50 MPa	OK
Cl. 5.8.2	Design flexural strength (modulus of rupture)	4.50×1.1 (90-day)	4.95 MPa	
Cl. 5.6, Table 1	Maximum positive temperature differential (day)	zone III, slab 290 mm (next tabulated thickness)	16.8 deg C	
Cl. 5.6.2.3	Negative differential for top-down cracking (night)	$16.8 / 2 + 5$ (built-in curl)	13.4 deg C	
App. V	Radius of relative stiffness $l = [E h^3 / 12 k (1 - \mu^2)]^{0.25}$	$[30,000 \times 0.290^3 / (12 \times 283.6 \times (1 - 0.15^2))]^{0.25}$	0.6848 m	

Table 1 - recommended maximum temperature differentials (deg C)

Zone	States / regions	150 mm	200 mm	250 mm	300 - 400 mm
I	Hilly regions of Uttarakhand, West Bengal, J&K, Himachal Pradesh, Arunachal Pradesh	12.5	13.1	14.3	15.8
II	Punjab, U.P., Uttarakhand, Gujarat, Rajasthan, Haryana, North M.P. (excluding hilly regions)	12.5	13.1	14.3	15.8
III	Bihar, Jharkhand, West Bengal, Assam, Eastern Odisha (excluding hilly and coastal areas)	15.6	16.4	16.6	16.8
IV	Maharashtra, Karnataka, South M.P., Chhattisgarh, Andhra Pradesh, Western Odisha, North Tamil Nadu	17.3	19	20.3	21
V	Kerala and South Tamil Nadu (excluding hilly and coastal areas)	15	16.4	17.6	18.1
VI	Coastal areas bounded by hills	14.6	15.8	16.2	17
VII	Coastal areas unbounded by hills	15.5	17	19	19.2

4. Design traffic and axle load repetitions

Design axle load repetitions (Cl. 5.5 and 6.3.3)				OK
Reference	Description	Calculation	Result	
Cl. 5.5.2.7	Initial CVPD at opening $A = P (1 + r)^x$	$6,000 \times (1 + 0.075)^0$	6,000 CVPD	
Eq. 1	Cumulative commercial vehicles $C = 365 A [(1 + r)^n - 1] / r$	$365 \times 6,000 \times 103.399$	226,444,692	
Cl. 5.5.2.6	Total axle repetitions	$226,444,692 \times 2.35$ axles / CV	532,145,025	
Cl. 5.5.2.3	Design lane axle repetitions	$\times 50\%$ predominant direction $\times 25\%$ (lateral placement)	66,518,128	
Cl. 6.3.3	Night (12 h) / day (12 h) axle repetitions	60 % / 40 %	39,910,877 / 26,607,251	
Cl. 6.3.3	Six-hour day-time repetitions - bottom-up cracking	$26,607,251 / 2$	13,303,626	
Cl. 5.5.2.4	Six-hour night-time repetitions - top-down cracking	$39,910,877 / 2 \times 55\%$ (wheel base < joint spacing)	10,975,491	

Category-wise axle repetitions for fatigue analysis

Axle category	Proportion %	Bottom-up cracking (6 h day)	Top-down cracking (6 h night)
Front (steering) single	45	5,986,632	4,938,971
Rear single	15	1,995,544	1,646,324
Tandem	25	3,325,906	2,743,873
Tridem	15	1,995,544	1,646,324

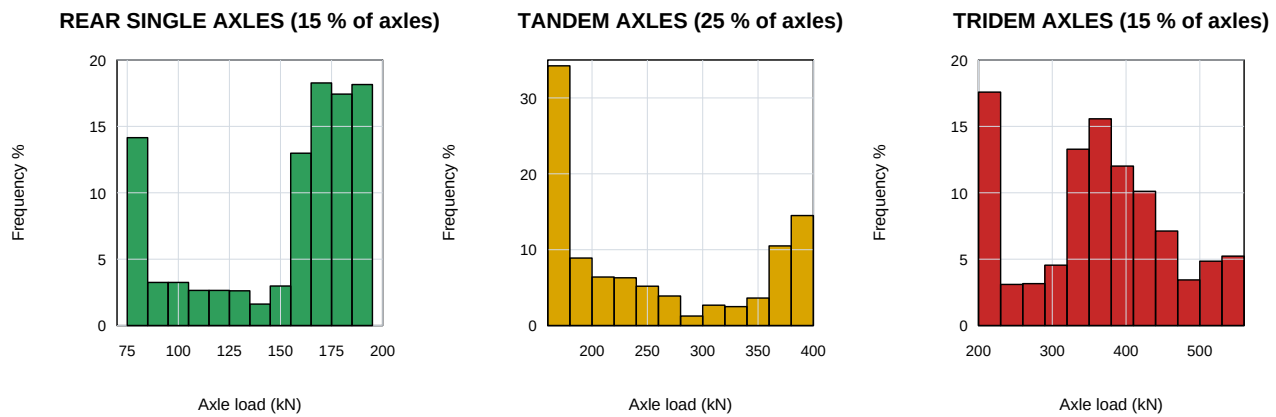


Fig. 2 Axle load spectrum (frequency of each load class)

5. Bottom-up cracking (BUC) fatigue analysis

Flexural stress at the bottom of the slab at the longitudinal edge, mid-panel, for the day-time positive temperature differential $dT = 16.8$ deg C, $k = 283.6$ MPa/m, $h = 290$ mm, $l = 0.6848$ m. $S = a + b (\gamma h^2 / k l^2) + c (P h / k l^4) + d dT$ with the coefficients for pavements with tied concrete shoulders. Load at the mid-point of each class. Front axles cause negligible bottom-up damage and are not analysed (Cl. 5.5.2.6).

Bottom-up cracking - rear single axles (Eq. V.3), expected repetitions 1,995,544

Load class (kN)	P (kN)	Expected reps ni	Stress S (MPa)	SR = S / MR	Allowable reps Ni	Damage ni / Ni
185 - 195	190	362,191	2.399	0.485	1,760,710	0.2057
175 - 185	180	347,823	2.324	0.470	5,423,706	0.0641
165 - 175	170	364,586	2.249	0.454	30,580,849	0.0119
155 - 165	160	259,022	2.174	0.439	unlimited	0.0000
145 - 155	150	59,467	2.098	0.424	unlimited	0.0000
135 - 145	140	32,328	2.023	0.409	unlimited	0.0000
125 - 135	130	52,283	1.948	0.393	unlimited	0.0000
115 - 125	120	52,882	1.872	0.378	unlimited	0.0000
105 - 115	110	52,882	1.797	0.363	unlimited	0.0000
95 - 105	100	64,855	1.722	0.348	unlimited	0.0000
85 - 95	90	64,855	1.646	0.333	unlimited	0.0000
75 - 85	80	282,369	1.571	0.317	unlimited	0.0000
Total		1,995,544				0.2818

Bottom-up cracking - tandem axles (Eq. V.9), expected repetitions 3,325,906

Load class (kN)	P (kN)	Expected reps ni	Stress S (MPa)	SR = S / MR	Allowable reps Ni	Damage ni / Ni
380 - 400	390	482,256	2.023	0.409	unlimited	0.0000
360 - 380	370	349,220	1.955	0.395	unlimited	0.0000
340 - 360	350	120,730	1.887	0.381	unlimited	0.0000
320 - 340	330	83,148	1.819	0.367	unlimited	0.0000
300 - 320	310	89,467	1.751	0.354	unlimited	0.0000
280 - 300	290	41,906	1.683	0.340	unlimited	0.0000
260 - 280	270	129,710	1.615	0.326	unlimited	0.0000
240 - 260	250	172,615	1.547	0.313	unlimited	0.0000
220 - 240	230	209,532	1.480	0.299	unlimited	0.0000
200 - 220	210	212,858	1.412	0.285	unlimited	0.0000
180 - 200	190	296,006	1.344	0.271	unlimited	0.0000
160 - 180	170	1,138,458	1.276	0.258	unlimited	0.0000
Total		3,325,906				0.0000

6. Top-down cracking (TDC) fatigue analysis

Flexural stress at the top of the slab with the front axle near one transverse joint and one rear axle near the next joint of the same panel, night-time negative differential 13.4 deg C (Eq. V.13): $S = -0.219 + 1.686 \beta P h / k l^4 + 168.48 h^2 / k l^2 + 0.1089 dT$ with $\beta = 0.66$ (doweled transverse joints). $P = 100\%$ of a rear single axle, 50% of a tandem and 33% of a tridem axle unit.

Top-down cracking - rear single axles, expected repetitions 1,646,324

Load class (kN)	P on panel (kN)	Expected reps ni	Stress S (MPa)	SR	Allowable reps Ni	Damage ni / Ni
185 - 195	190.0	298,808	2.330	0.471	4,914,906	0.0608
175 - 185	180.0	286,954	2.278	0.460	13,988,641	0.0205
165 - 175	170.0	300,783	2.226	0.450	unlimited	0.0000
155 - 165	160.0	213,693	2.175	0.439	unlimited	0.0000
145 - 155	150.0	49,060	2.123	0.429	unlimited	0.0000
135 - 145	140.0	26,670	2.071	0.418	unlimited	0.0000
125 - 135	130.0	43,134	2.019	0.408	unlimited	0.0000
115 - 125	120.0	43,628	1.968	0.397	unlimited	0.0000
105 - 115	110.0	43,628	1.916	0.387	unlimited	0.0000
95 - 105	100.0	53,506	1.864	0.377	unlimited	0.0000
85 - 95	90.0	53,506	1.812	0.366	unlimited	0.0000
75 - 85	80.0	232,955	1.761	0.356	unlimited	0.0000
Total		1,646,324				0.0813

Top-down cracking - tandem axles, expected repetitions 2,743,873

Load class (kN)	P on panel (kN)	Expected reps ni	Stress S (MPa)	SR	Allowable reps Ni	Damage ni / Ni
380 - 400	195.0	397,862	2.356	0.476	3,231,123	0.1231
360 - 380	185.0	288,107	2.304	0.465	7,953,318	0.0362
340 - 360	175.0	99,603	2.252	0.455	27,695,605	0.0036
320 - 340	165.0	68,597	2.200	0.445	unlimited	0.0000
300 - 320	155.0	73,810	2.149	0.434	unlimited	0.0000
280 - 300	145.0	34,573	2.097	0.424	unlimited	0.0000
260 - 280	135.0	107,011	2.045	0.413	unlimited	0.0000
240 - 260	125.0	142,407	1.993	0.403	unlimited	0.0000
220 - 240	115.0	172,864	1.942	0.392	unlimited	0.0000
200 - 220	105.0	175,608	1.890	0.382	unlimited	0.0000
180 - 200	95.0	244,205	1.838	0.371	unlimited	0.0000
160 - 180	85.0	939,228	1.787	0.361	unlimited	0.0000
Total		2,743,873				0.1630

Top-down cracking - tridem axles, expected repetitions 1,646,324

Load class (kN)	P on panel (kN)	Expected reps ni	Stress S (MPa)	SR	Allowable reps Ni	Damage ni / Ni
530 - 560	181.7	86,103	2.287	0.462	11,461,434	0.0075
500 - 530	171.7	79,847	2.235	0.451	48,016,259	0.0017
470 - 500	161.7	56,634	2.183	0.441	unlimited	0.0000
440 - 470	151.7	117,218	2.131	0.431	unlimited	0.0000
410 - 440	141.7	166,443	2.080	0.420	unlimited	0.0000
380 - 410	131.7	197,723	2.028	0.410	unlimited	0.0000
350 - 380	121.7	256,333	1.976	0.399	unlimited	0.0000
320 - 350	111.7	218,632	1.925	0.389	unlimited	0.0000
290 - 320	101.7	74,908	1.873	0.378	unlimited	0.0000
260 - 290	91.7	52,024	1.821	0.368	unlimited	0.0000
230 - 260	81.7	51,036	1.769	0.357	unlimited	0.0000
200 - 230	71.7	289,424	1.718	0.347	unlimited	0.0000
Total		1,646,324				0.0092

CRITICAL LOAD POSITIONS (IRC:58-2015 FIGS. 3 TO 6)

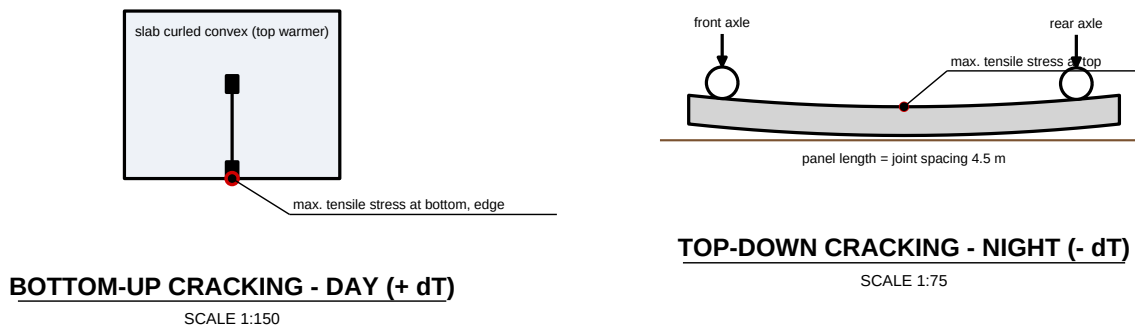


Fig. 3 Critical load positions for bottom-up and top-down cracking

7. Cumulative fatigue damage and slab thickness

Cumulative fatigue damage for $h = 290$ mm				OK
Reference	Description	Calculation	Result	
Eq. 7	CFD bottom-up cracking	$0.282 \text{ (single)} + 0.000 \text{ (tandem)}$	0.282	
Eq. 8	CFD top-down cracking	$0.081 + 0.163 + 0.009$	0.253	
Cl. 6.3.4.1	CFD(BUC) + CFD(TDC) ≤ 1	$0.282 + 0.253$	0.535	OK
Cl. 6.3.4.1	Add 10 mm for two retexturings / grinding	$290 + 10$	300 mm	

Adopt PQC thickness 300 mm (design thickness 290 mm, total CFD 0.535).

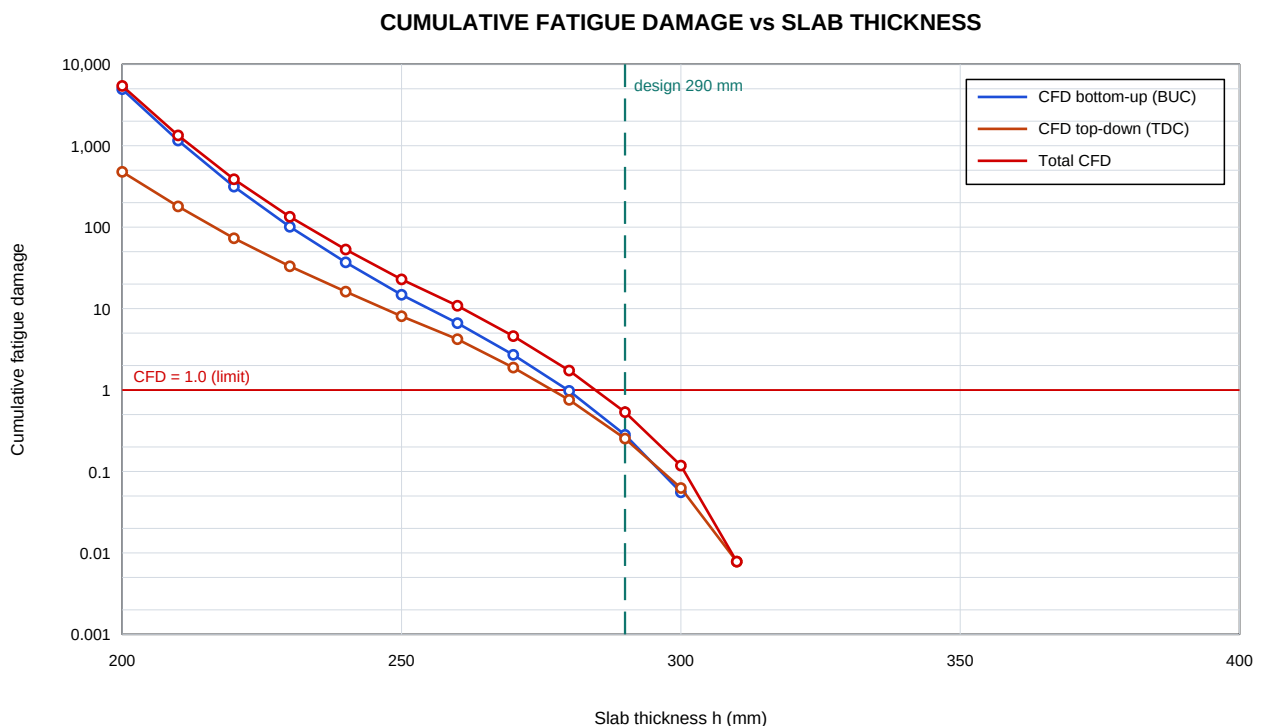


Fig. 4 Cumulative fatigue damage for the trial thicknesses (log scale)

Trial thicknesses (as Table VII.4 of IRC:58-2015)

h (mm)	dT day	BUC single	BUC tandem	TDC single	TDC tandem	TDC tridem	Total CFD	Result
200	16.4	4616.417	327.450	182.603	258.071	37.059	5421.601	NOT OK
210	16.6	1074.250	83.848	69.969	94.496	15.262	1337.825	NOT OK
220	16.6	289.920	24.474	28.967	37.529	6.536	387.425	NOT OK
230	16.6	92.807	8.228	13.380	16.728	2.965	134.108	NOT OK

h (mm)	dT day	BUC single	BUC tandem	TDC single	TDC tandem	TDC tridem	Total CFD	Result
240	16.6	34.212	2.776	6.613	8.166	1.373	53.140	NOT OK
250	16.6	14.053	0.729	3.270	4.176	0.612	22.841	NOT OK
260	16.8	6.493	0.136	1.675	2.249	0.286	10.839	NOT OK
270	16.8	2.706	0.000	0.724	1.054	0.109	4.593	NOT OK
280	16.8	0.977	0.000	0.275	0.447	0.036	1.734	NOT OK
290	16.8	0.282	0.000	0.081	0.163	0.009	0.535	OK
300	16.8	0.056	0.000	0.016	0.046	0.000	0.118	OK
310	16.8	0.000	0.000	0.000	0.008	0.000	0.008	OK
320	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
330	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
340	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
350	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
360	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
370	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
380	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
390	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK
400	16.8	0.000	0.000	0.000	0.000	0.000	0.000	OK

FATIGUE DAMAGE BY AXLE CATEGORY (h = 290 mm)

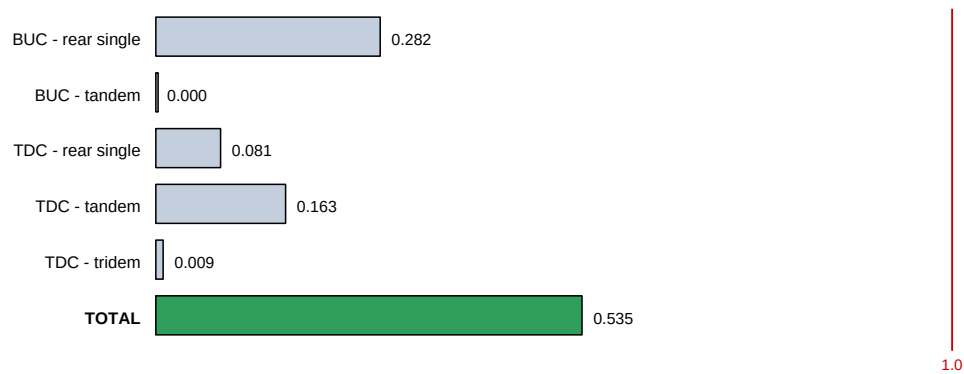


Fig. 5 Fatigue damage by axle category at the design thickness

STRESS RATIO vs AXLE LOAD (h = 290 mm)

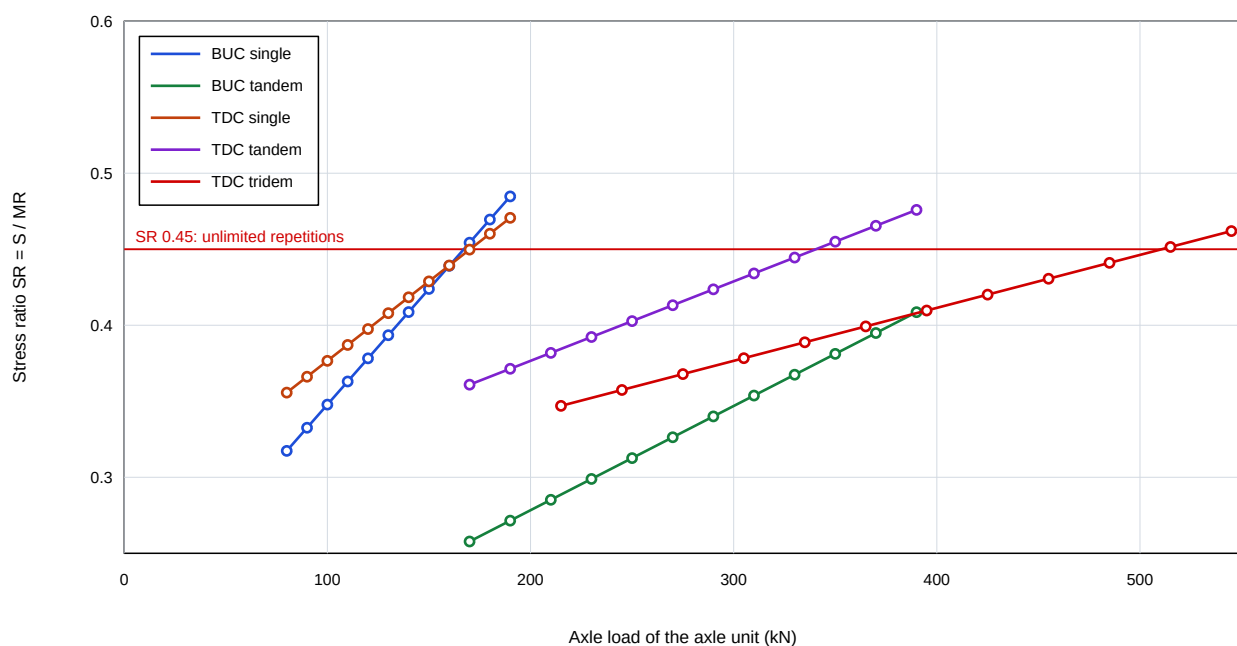


Fig. 6 Stress ratio against axle load at the design thickness

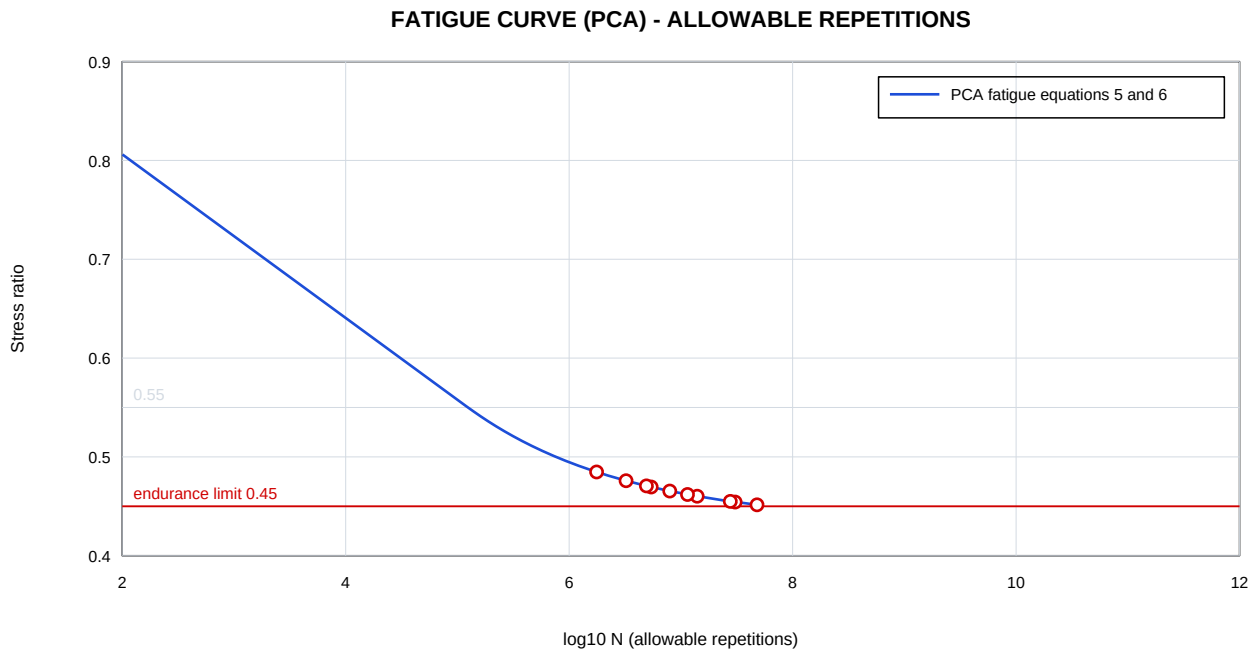


Fig. 7 PCA fatigue relationship with the design load classes

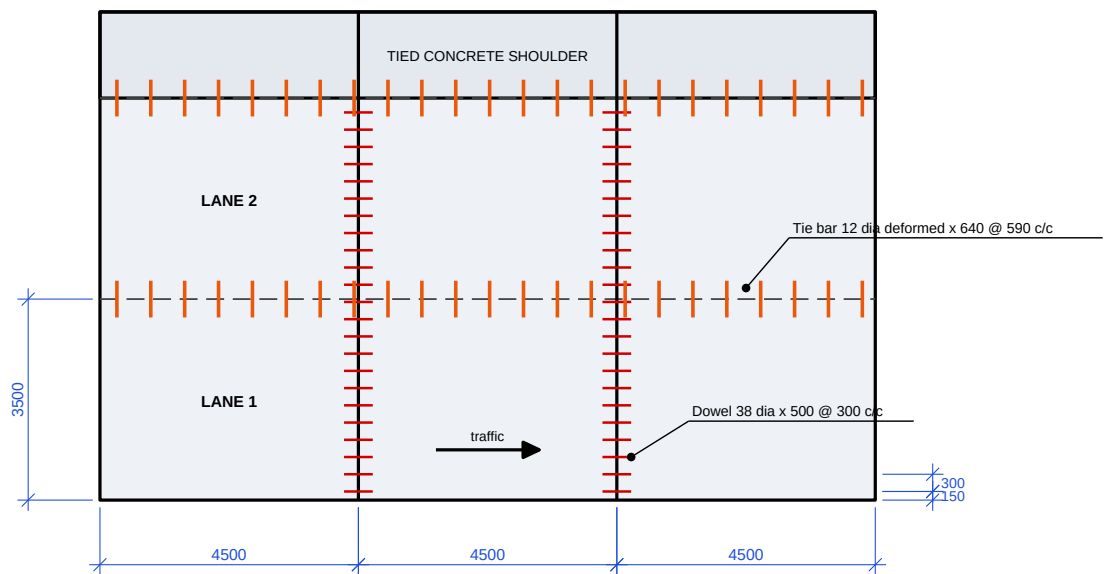
8. Joints, dowel bars and tie bars

Contraction joints at 4.5 m (Cl. 7.1.3, not more than 4.5 m to prevent top-down cracking), sawn to 1/4 - 1/3 of the depth and sealed; expansion joints only next to bridges and culverts; longitudinal joints between lanes and at the tied shoulder (Cl. 7.1.6).

Dowel bars at transverse joints (Cl. 7.2, Appendix VIII)				OK
Reference	Description	Calculation	Result	
Table 5	Dowel bar for the slab thickness	$h = 300 \text{ mm} \rightarrow \text{row } 300 \text{ mm}$	38 dia x 500 @ 300 mm	
App. VIII	Design wheel load (dual wheels as one)	190 kN max. single axle / 2	95.0 kN	
App. VIII	Load transferred by the dowel system	$95.0 \times (1 - 30\% \text{ to shoulder}) \times 50 \%$	33.25 kN	
Cl. 7.2.7	Dowels within l participating (linear distribution)	$l = 685 \text{ mm, spacing } 300 \text{ mm: } 1.000 + 0.562 + 0.124$	1.686 Pt	
Cl. 7.2.7	Load on the outermost dowel Pt	$33.25 / 1.686$	19.72 kN	
Eq. 14	Relative stiffness $\beta = [\text{kmds } bd / (4 E l)]^{0.25}$	$l = \pi \times 38^4 / 64 = 102,354 \text{ mm}^4; \text{kmds} = 415,000 \text{ MPa/m}$	0.0209 /mm	
Eq. 14	Max. bearing stress, contraction joint $z = 5 \text{ mm}$	$Pt \text{ kmds } (2 + \beta z) / (4 \beta^3 E l)$	22.89 MPa	OK
Eq. 14	Max. bearing stress, expansion joint $z = 20 \text{ mm}$		26.30 MPa	OK
Eq. 15	Allowable bearing stress $F_b = (101.6 - bd) f_{ck} / 95.25$	$(101.6 - 38) \times 40 / 95.25$	26.71 MPa	

Tie bars at longitudinal joints (Cl. 8, Appendix IX)				OK
Reference	Description	Calculation	Result	
Eq. 16	Steel per m of joint $A_s = b f W / S_{st}$	$3.5 \times 1.5 \times 7.20 \times 1000 / 200$	189.0 mm ² /m	
Cl. 8.2	Spacing of 12 mm deformed bars	$113.1 / 189.0 \times 1000 = 598.4$	590 mm c/c	OK
Eq. 17	Bond length $L = 2 S_{st} A / (B P)$	$2 \times 200 \times 113.1 / (2.46 \times 37.7)$	487.8 mm	

Reference	Description	Calculation	Result	
App. IX	Length incl. 100 mm (paint) + 50 mm (placement)	487.8 + 150	640 mm	
Table 6	Recommended minimum length for the slab thickness	12 mm deformed	640 mm	
-	Adopted tie bar		12 mm x 640 @ 590 c/c	



SLAB LAYOUT - JOINTS, DOWEL AND TIE BARS (PLAN)

SCALE 1:125

Fig. 8 Slab layout with joints, dowel bars and tie bars

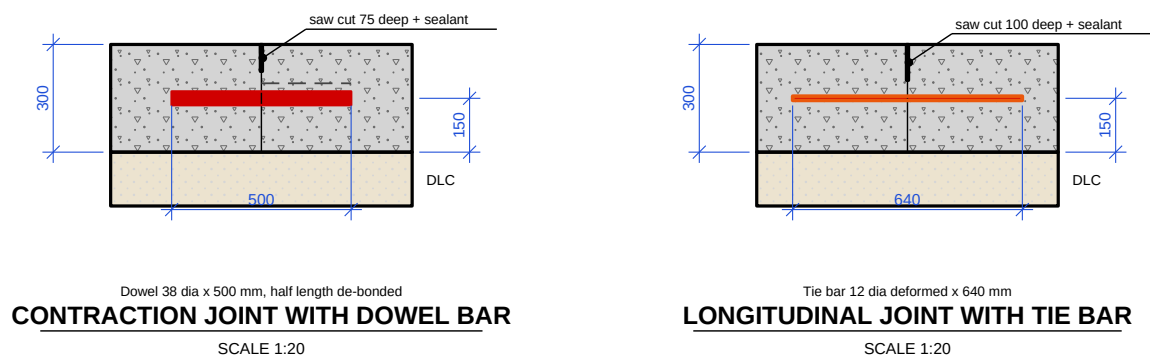


Fig. 9 Joint details

9. Design summary and recommendations

Pavement quality concrete M40, flexural strength 4.50 MPa (28 days): 300 mm thick.

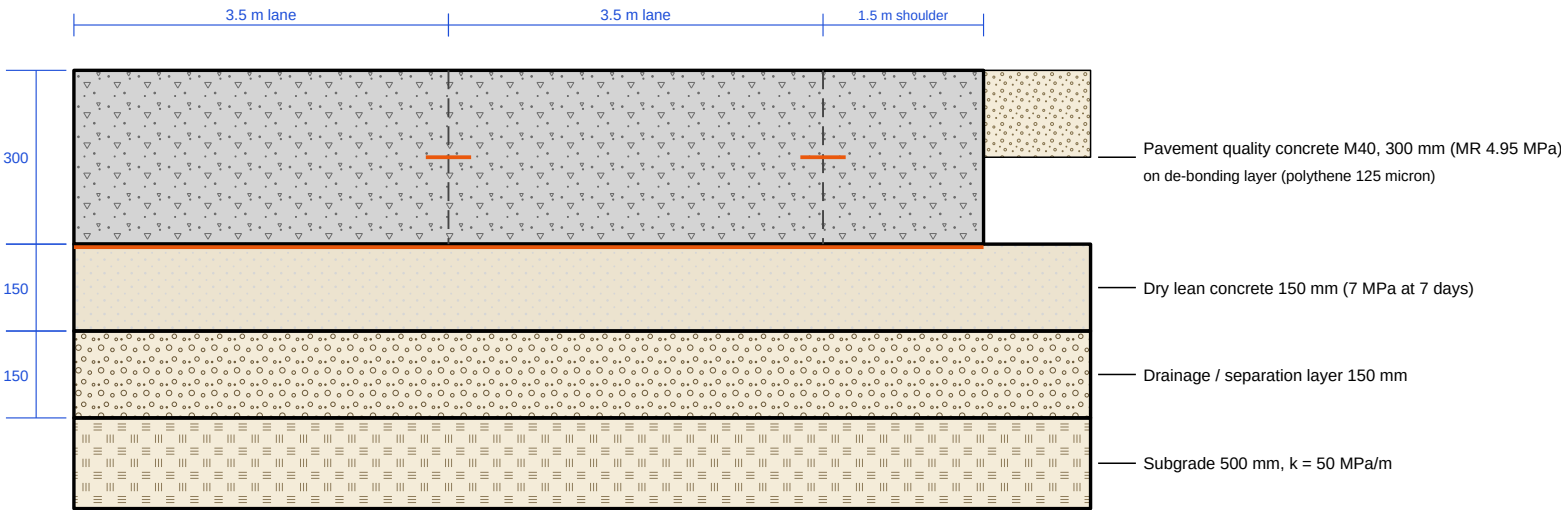
Foundation: dry lean concrete (dlc) over granular drainage / separation layer 150 mm, effective $k = 284 \text{ MPa/m}$.

Contraction joints @ 4.5 m with 38 mm dowels x 500 mm @ 300 mm c/c; tie bars 12 mm x 640 mm @ 590 mm c/c.

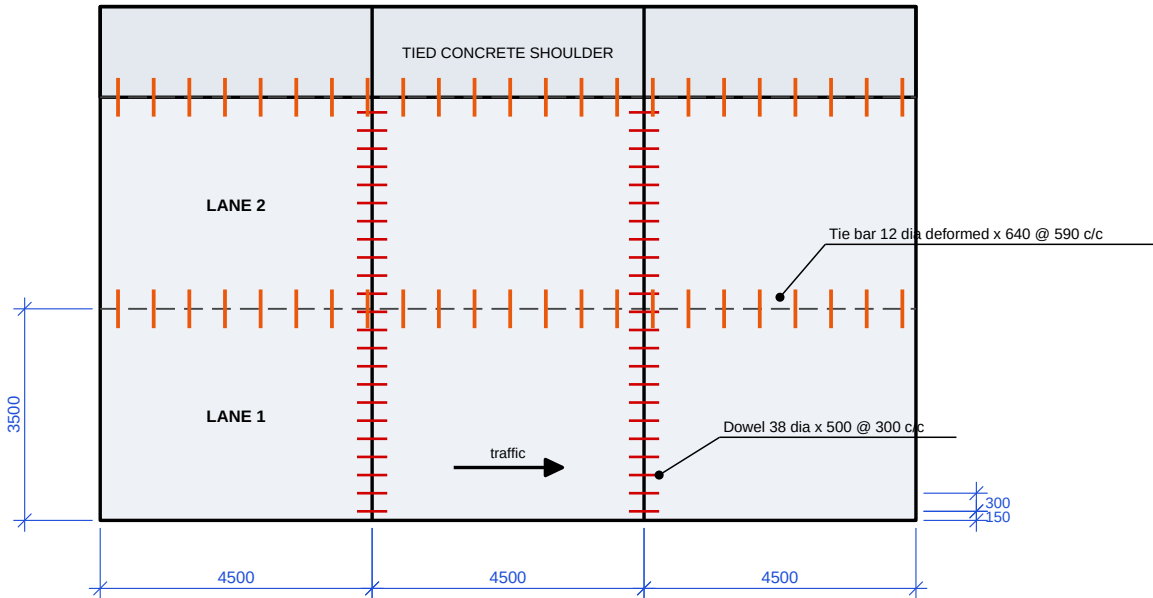
Provide a drainage layer of permeability $\geq 300 \text{ m/day}$ below the DLC where rainfall exceeds 1000 mm (Cl. 6.5) and a 125 micron polythene de-bonding layer between DLC and PQC (Cl. 5.7.5).

Report generated 31 Oct 2026. The bonded PQC-on-DLC option (Cl. 6.7) is not covered by this program.

TYPICAL CROSS SECTION (SCHEMATIC)

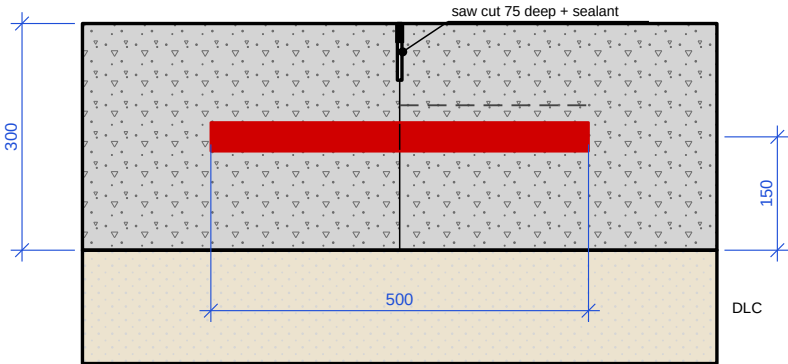


Layer thicknesses not to scale (vertical exaggeration). Longitudinal joints with tie bars shown dashed.



SLAB LAYOUT - JOINTS, DOWEL AND TIE BARS (PLAN)

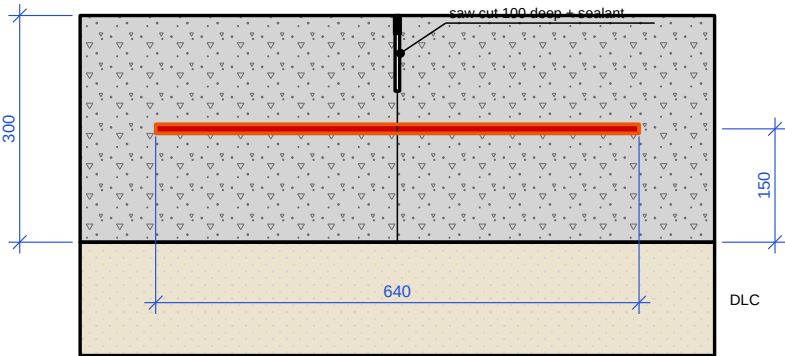
SCALE 1:125



CONTRACTION JOINT WITH DOWEL BAR

SCALE 1:10

Dowel 38 dia x 500 mm, half length de-bonded

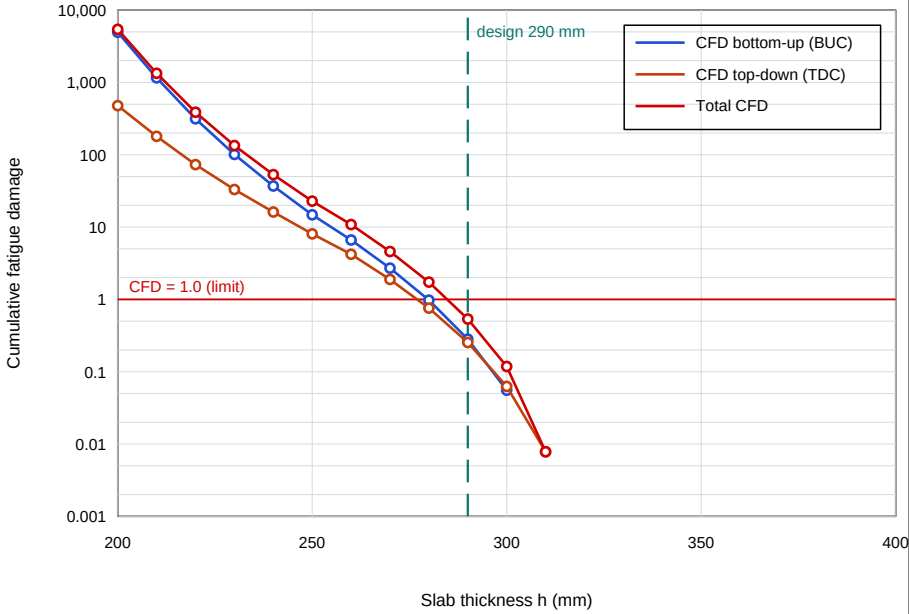


LONGITUDINAL JOINT WITH TIE BAR

SCALE 1:10

Tie bar 12 dia deformed x 640 mm

CFD vs SLAB THICKNESS



DESIGN SUMMARY (IRC:58-2015)

Design thickness (CFD <= 1)	290 mm
Adopted PQC thickness	300 mm (incl. 10 mm for retexturing)
CFD bottom-up / top-down	0.282 / 0.253
Total CFD	0.535 <= 1.0
Effective k of foundation	283.6 MPa/m
Design flexural strength	4.95 MPa (90-day)
Temperature differential day / night	16.8 / 13.4 deg C
Radius of relative stiffness l	685 mm
Design traffic (CVs, design period)	226.44 million
Axle repetitions BUC / TDC (6 h)	13.30 / 10.98 million
Dowel bars	38 mm dia x 500 mm @ 300 mm c/c
Tie bars	12 mm deformed x 640 mm @ 590 mm c/c
Contraction joint spacing	4.5 m

Result: **SAFE - CFD <= 1**

NOTES

- All dimensions in mm unless noted otherwise.
- PQC to MORTH Section 600; DLC 7 MPa at 7 days (IRC:SP:49).
- Polythene 125 micron de-bonding layer between DLC and PQC.
- Dowels plain MS, half length de-bonded; tie bars to IS 1786.
- Joints sawn and sealed as per IRC:57; spacing <= 4.5 m.

IRC 58 example check

Rigid pavement 300 mm PQC

Designed: - Checked: -

Date: 31 Oct 2026 Scale: as shown Sheet 1 of 1