DESIGN REPORT

Bituminous pavement - 130.9 msa

Designed in accordance with IRC:37-2018 (mechanistic-empirical method)

Project	-
Client	-
Location	-
Chainage / section	-
Design	IRC 37 example check
Designed by	-
Checked by	-
Design traffic	130.91 msa (90 % reliability)
Pavement (mm)	Bituminous layers 100 + Aggregate interlayer 100 + Cement treated base 180 + Cement treated sub-base 250
Result	ALL CHECKS SATISFIED
Date	31 Oct 2026

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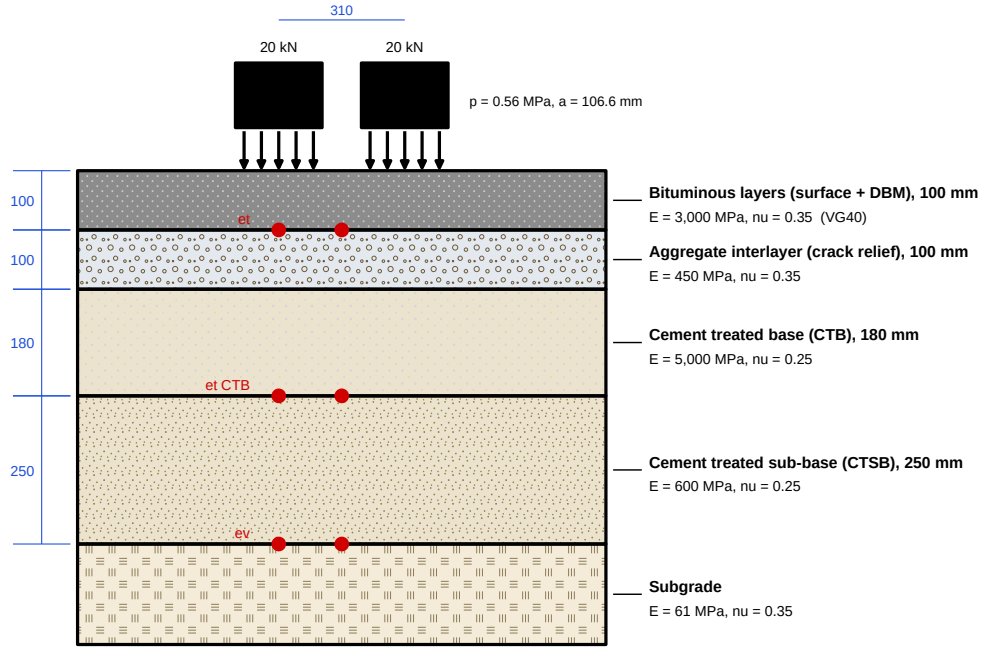
1. Design basis and input data

Bituminous pavement designed to IRC:37-2018 (Guidelines for the Design of Flexible Pavements, fourth revision) by the mechanistic-empirical method: the pavement is analysed as a linear elastic, fully bonded layered system under the standard axle (dual wheels of 20 kN at 0.56 MPa, 310 mm c/c; 0.80 MPa for the cement treated base) and the computed critical strains are compared with the allowable strains of the performance models for subgrade rutting (Eq. 3.1/3.2), bottom-up fatigue cracking of the bituminous layer (Eq. 3.3/3.4) and fatigue of the CTB (Eq. 3.5 - 3.7). The layered elastic analysis performed by IITPAVE is carried out by this program (Burmister multilayer solution); its results agree with the IITPAVE values of Annexes II and III within about 1 %.

Project	-
Client	-
Location / chainage	-
Road category	National Highway
Carriageway	Dual carriageway - two lanes each way
Composition	Bituminous + aggregate interlayer + CTB + CTSB
Design period	20 years
Bituminous binder (DBM)	BC and DBM with VG40 bitumen; average annual pavement temperature 35 deg C

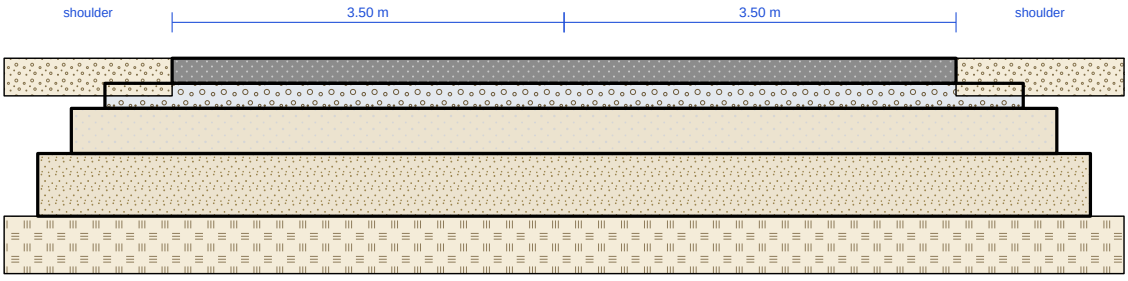
PAVEMENT COMPOSITION AND CRITICAL LOCATIONS



Thicknesses to scale vertically; subgrade semi-infinite. Red dots: critical strain locations (Table 3.1).

Fig. 1 Pavement composition, standard load and critical locations

TYPICAL CROSS SECTION (SCHEMATIC)



Dual carriageway - two lanes each way - layer thicknesses exaggerated; total pavement 630 mm.

Fig. 2 Typical cross section (schematic)

2. Design traffic

Cumulative standard axles (Cl. 4.6)				OK
Reference	**Description**	**Calculation**	**Result**	
Cl. 4.5	**Lateral distribution factor D**	Dual carriageway - two lanes each way	**0.75**	
Eq. 4.6	**Traffic in the year of completion A = P (1 + r)^x**	5,000 x 50 % (directional) x (1 + 0.06)^0	**2,500 CVPD**	
Cl. 4.4 / Table 4.2	**Vehicle damage factor F**	axle load survey	**5.2**	
Eq. 4.5	**N = 365 [(1 + r)^n - 1] / r x A x D x F**	365 x 36.786 x 2,500 x 0.75 x 5.2	**130,910,723 = 130.91 msa**	
Cl. 3.7	**Reliability of the performance models**	important road	**90 %**	

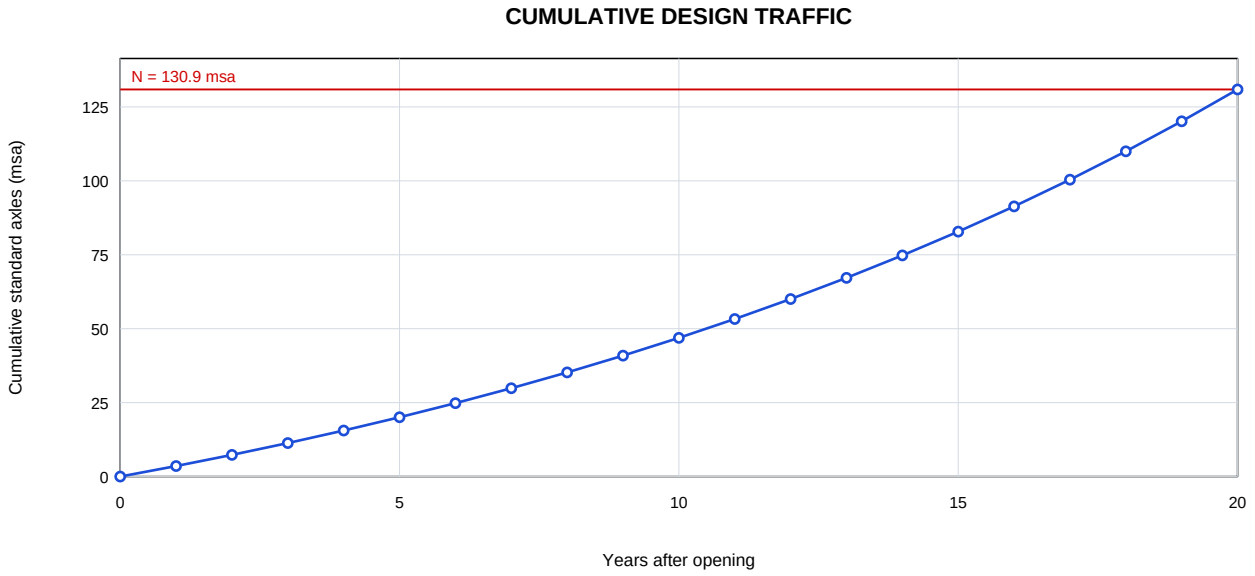


Fig. 3 Growth of cumulative standard axles over the design period

3. Subgrade - effective resilient modulus

Resilient modulus of the subgrade (Cl. 6.3, 6.4)				OK
Reference	**Description**	**Calculation**	**Result**	
Eq. 6.1 / 6.2	**Resilient modulus of the 500 mm subgrade**	17.6 x 7^0.64	**61.1 MPa**	
Eq. 6.2	**Effective CBR reported**		**7.0 %**	

4. Layer properties for analysis

Layers analysed (Table 11.1); bituminous layers as one layer with the DBM modulus

Layer	Thickness (mm)	E (MPa)	Poisson's ratio	Basis
Bituminous layers (surface + DBM)	100	3,000	0.35	Table 9.2 (BC and DBM with VG40 bitumen at 35 deg C)
Aggregate interlayer (crack relief)	100	450	0.35	Cl. 8.3 / Table 11.1
Cement treated base (CTB)	180	5,000	0.25	Cl. 8.2 / Table 11.1
Cement treated sub-base (CTSB)	250	600	0.25	Cl. 7.3.2 / Table 11.1
Subgrade	semi-infinite	61	0.35	Cl. 6

Bituminous mix parameters				OK
Reference	**Description**	**Calculation**	**Result**	
Cl. 9.2	**Volume of air voids / effective bitumen of the bottom DBM**	mix design	**Va = 3 %, Vbe = 11.5 %**	

Reference	Description	Calculation	Result	
Eq. 3.3	**Mix adjustment C = 10^(4.84 (Vbe / (Va + Vbe) - 0.69))**	10^(4.84 x (11.5 / 14.5 - 0.69))	**3.155**	

5. Structural analysis - linear elastic layered system

Standard axle: one set of dual wheels, 20 kN each, 310 mm c/c, uniform contact stress 0.56 MPa (contact radius 106.6 mm); fully bonded interfaces (Table 3.1). Responses at the bottom of the bituminous layer, the bottom of the CTB and the top of the subgrade, under the centre of one wheel (x = 0) and midway between the wheels (x = 155 mm). Strains in microstrain, tension positive; x along the line joining the wheels.

Computed responses at the critical locations

Location	x (mm)	ex	ey	ez	Vertical stress (MPa)
Bottom of bituminous layer, z = 100 mm	0	89.7	127.5	-172.6	-0.2678
Bottom of bituminous layer, z = 100 mm	155	-79.0	108.5	-54.1	-0.1840
Bottom of CTB, z = 380 mm (0.80 MPa)	0	29.3	41.3	-29.7	sx 0.199 / sy 0.247
Bottom of CTB, z = 380 mm (0.80 MPa)	155	33.0	44.3	-32.7	sx 0.222 / sy 0.266
Top of subgrade, z = 630 mm	0	52.8	62.7	-159.1	-0.0095
Top of subgrade, z = 630 mm	155	58.7	65.3	-168.6	-0.0100

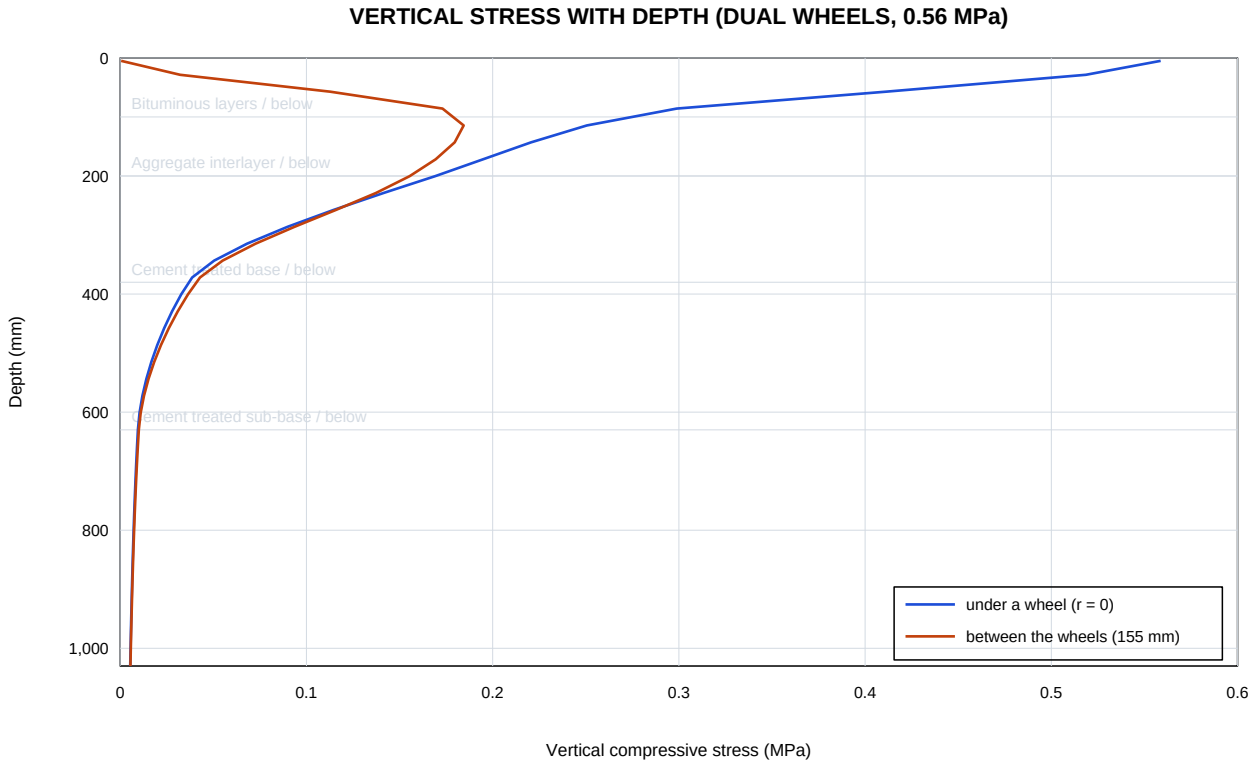


Fig. 4 Vertical compressive stress with depth

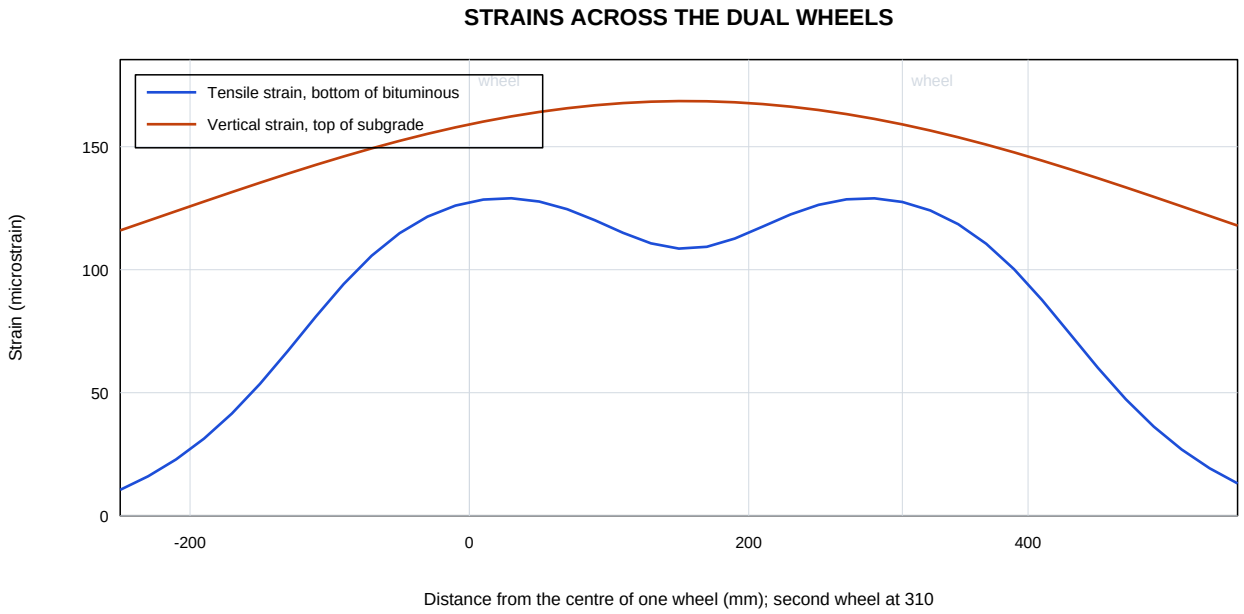


Fig. 5 Critical strains across the dual wheel set

6. Performance checks

Performance criteria (Cl. 3.6)				OK
Reference	**Description**	**Calculation**	**Result**	
Eq. 3.2	**Allowable subgrade strain (N = design traffic)**	(1.4100e-8 / 130,910,723)^(1/4.5337)	**300.6 microstrain**	
Analysis	**Computed vertical strain, top of subgrade**	max. of x = 0 and 155 mm	**168.6 microstrain**	**OK**
Eq. 3.2	**Rutting life NR**	1.4100e-8 (1 / 1.686e-04)^4.5337	**1,802.90 msa**	**OK**
Eq. 3.4	**Allowable tensile strain, bottom of bituminous layer**	(0.5161 x 3.155 x 1e-4 x 3,000^-0.854 / 130,910,723)^(1/3.89)	**150.0 microstrain**	
Analysis	**Computed tensile strain, bottom of bituminous layer**	max. of x = 0 and 155 mm	**127.5 microstrain**	**OK**
Eq. 3.4	**Fatigue life Nf**	0.5161 x 3.155 x 1e-4 (1 / 1.275e-04)^3.89 (1 / 3,000)^0.854	**246.26 msa**	**OK**
Eq. 3.5	**CTB life N = RF [(113000 / E^0.804 + 191) / et]^12, RF = 1**	1 x [(113000 / 5,000^0.804 + 191) / 44.3]^12	**14,400.79 msa**	**OK**

Summary of checks

Check	Reference	Computed	Limit	Result
Subgrade rutting - vertical strain on subgrade	Eq. 3.1/3.2	168.561 microstrain	300.598 microstrain	**OK**
Bituminous fatigue - tensile strain at bottom	Eq. 3.3/3.4	127.535 microstrain	150.029 microstrain	**OK**
CTB fatigue - life from tensile strain (0.80 MPa)	Eq. 3.5	130.911 msa	14,400.792 msa	**OK**
CTB under construction traffic (7-day strength)	Eq. 3.6, II.4	0.698 MPa	0.795 MPa	**OK**
CTB cumulative fatigue damage (axle spectrum)	Eq. 3.6/3.7	0.788	1.000	**OK**
Minimum layer thicknesses	Cl. 7 - 9	0 issue(s)	0	**OK**

7. Cumulative fatigue damage of the cement treated base

Tensile stress at the bottom of the CTB for every axle load class at 0.80 MPa contact stress; tandem axles as two and tridem axles as three single axles (Cl. 3.6.3.2); modulus of rupture 1.4 MPa; log10 Nf = (0.972 - SR) / 0.0825.

Single axles - CFD 0.089

Load class (kN)	Axle load (kN)	Single axle reps ni	Stress (MPa)	SR	Fatigue life Nf	ni / Nf
185 - 195	190	70,000	0.604	0.431	3.571e+06	0.0196
175 - 185	180	90,000	0.575	0.410	6.415e+06	0.0140

Load class (kN)	Axle load (kN)	Single axle reps ni	Stress (MPa)	SR	Fatigue life Nf	ni / Nf
165 - 175	170	92,000	0.545	0.389	1.158e+07	0.0079
155 - 165	160	300,000	0.515	0.368	2.102e+07	0.0143
145 - 155	150	280,000	0.485	0.346	3.833e+07	0.0073
135 - 145	140	650,000	0.454	0.325	7.027e+07	0.0092
125 - 135	130	600,000	0.424	0.303	1.295e+08	0.0046
115 - 125	120	1,340,000	0.393	0.281	2.399e+08	0.0056
105 - 115	110	1,300,000	0.362	0.258	4.469e+08	0.0029
95 - 105	100	1,500,000	0.330	0.236	8.369e+08	0.0018
85 - 95	90	1,350,000	0.298	0.213	1.576e+09	0.0009
75 - 85	80	3,700,000	0.266	0.190	2.984e+09	0.0012

Tandem axles - CFD 0.548

Load class (kN)	Axle load (kN)	Single axle reps ni	Stress (MPa)	SR	Fatigue life Nf	ni / Nf
390 - 410	400	400,000	0.633	0.452	1.998e+06	0.2002
370 - 390	380	460,000	0.604	0.431	3.571e+06	0.1288
350 - 370	360	480,000	0.575	0.410	6.415e+06	0.0748
330 - 350	340	470,000	0.545	0.389	1.158e+07	0.0406
310 - 330	320	450,000	0.515	0.368	2.102e+07	0.0214
290 - 310	300	950,000	0.485	0.346	3.833e+07	0.0248
270 - 290	280	900,000	0.454	0.325	7.027e+07	0.0128
250 - 270	260	2,870,000	0.424	0.303	1.295e+08	0.0222
230 - 250	240	2,500,000	0.393	0.281	2.399e+08	0.0104
210 - 230	220	2,370,000	0.362	0.258	4.469e+08	0.0053
190 - 210	200	2,000,000	0.330	0.236	8.369e+08	0.0024
170 - 190	180	1,600,000	0.298	0.213	1.576e+09	0.0010
150 - 190	170	6,400,000	0.283	0.202	2.167e+09	0.0030

Tridem axles - CFD 0.151

Load class (kN)	Axle load (kN)	Single axle reps ni	Stress (MPa)	SR	Fatigue life Nf	ni / Nf
585 - 615	600	105,000	0.633	0.452	1.998e+06	0.0526
555 - 585	570	120,000	0.604	0.431	3.571e+06	0.0336
525 - 555	540	120,000	0.575	0.410	6.415e+06	0.0187
495 - 525	510	135,000	0.545	0.389	1.158e+07	0.0117
465 - 495	480	129,000	0.515	0.368	2.102e+07	0.0061
435 - 465	450	330,000	0.485	0.346	3.833e+07	0.0086
405 - 435	420	300,000	0.454	0.325	7.027e+07	0.0043
375 - 405	390	990,000	0.424	0.303	1.295e+08	0.0076
345 - 375	360	900,000	0.393	0.281	2.399e+08	0.0038
315 - 345	330	825,000	0.362	0.258	4.469e+08	0.0018
285 - 315	300	780,000	0.330	0.236	8.369e+08	0.0009
255 - 285	270	540,000	0.298	0.213	1.576e+09	0.0003
240 - 270	255	2,160,000	0.283	0.202	2.167e+09	0.0010

Total CTB cumulative fatigue damage = 0.089 + 0.548 + 0.151 = 0.788 <= 1.0

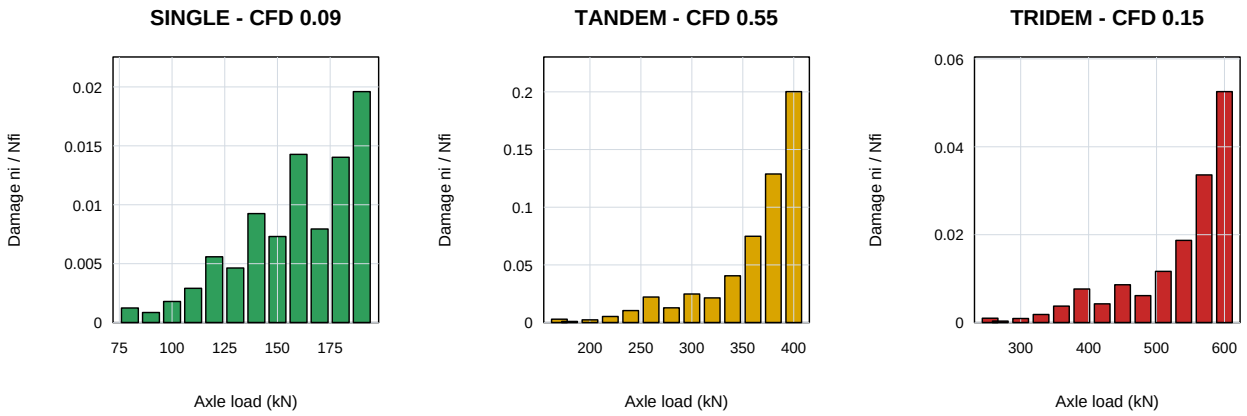


Fig. 6 CTB fatigue damage by axle load class

8. Construction traffic

Sub-base / CTB under construction traffic (Cl. 7.2.2, Annex II)			OK	
Reference	**Description**	**Calculation**	**Result**	
Annex II.2	**VDF of a dumper (rear tandem as two single axles)**	2 x (120 / 80)^4 + (80 / 65)^4	**12.42**	
Cl. 7.2.2 (v)	**Construction traffic (min. 10,000 SA)**	max(200 x 12.42, 10000)	**10,000 SA**	
Eq. 3.2	**Allowable subgrade strain**		**2433 microstrain**	
Eq. 3.6	**Allowable stress, 140 reps of 120 kN, 7-day MR 1 MPa**	1 (0.972 - 0.0825 log 140)	**0.795 MPa**	
Annex II.4	**Tensile stress at bottom of CTB (CTB + sub-base + subgrade, 0.80 MPa)**		**0.698 MPa**	**OK**

9. Bituminous layer thickness trials

Other layers as given; total bituminous thickness varied. Least thickness satisfying all life checks: 100 mm.

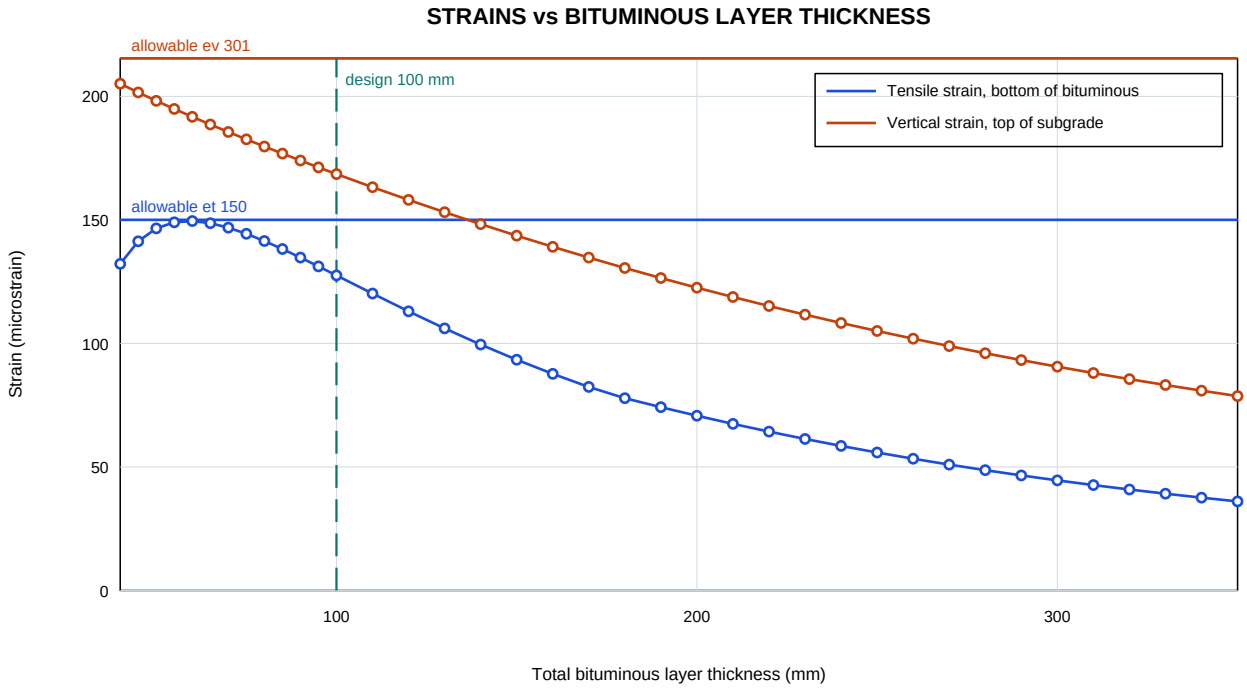


Fig. 7 Critical strains against bituminous layer thickness

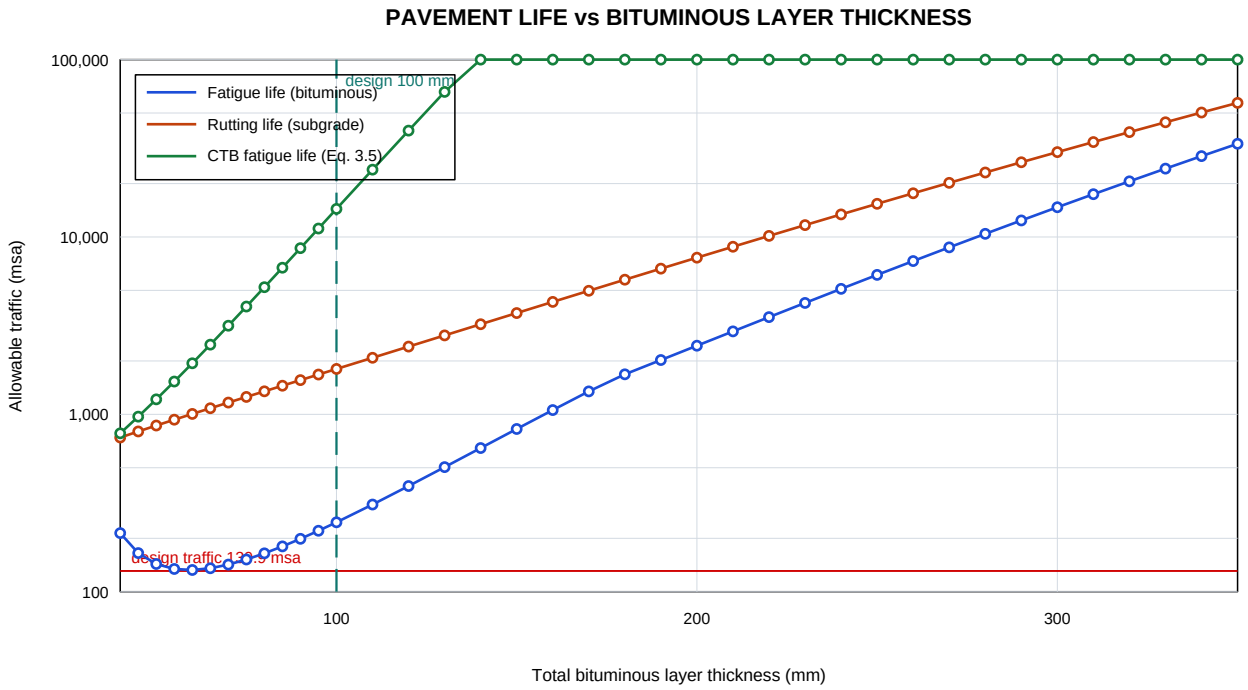


Fig. 8 Allowable traffic against bituminous layer thickness

Trial thicknesses

Bituminous (mm)	et	ev	Fatigue life	Rutting life	CTB life	Result
40	132.2	205.1	214.02 msa	740.17 msa	781.65 msa	NOT OK
45	141.3	201.6	165.12 msa	800.86 msa	970.69 msa	NOT OK
50	146.6	198.2	143.34 msa	865.01 msa	1,214.91 msa	NOT OK
55	149.0	194.9	134.36 msa	933.06 msa	1,531.00 msa	NOT OK
60	149.5	191.7	132.60 msa	1,005.47 msa	1,940.56 msa	NOT OK
65	148.7	188.6	135.61 msa	1,082.72 msa	2,471.57 msa	NOT OK
70	146.9	185.6	142.23 msa	1,165.30 msa	3,160.19 msa	NOT OK
75	144.4	182.6	151.95 msa	1,253.71 msa	4,053.11 msa	NOT OK
80	141.5	179.7	164.57 msa	1,348.48 msa	5,210.51 msa	NOT OK
85	138.2	176.9	180.11 msa	1,450.18 msa	6,709.82 msa	NOT OK
90	134.8	174.0	198.73 msa	1,559.40 msa	8,650.46 msa	NOT OK
95	131.2	171.3	220.67 msa	1,676.75 msa	11,159.82 msa	NOT OK
100	127.5	168.6	246.26 msa	1,802.90 msa	14,400.79 msa	OK
110	120.2	163.3	310.10 msa	2,084.42 msa	23,965.69 msa	OK
120	113.0	158.1	394.30 msa	2,410.05 msa	39,781.45 msa	OK
130	106.1	153.1	504.05 msa	2,786.67 msa	65,759.59 msa	OK
140	99.5	148.3	645.72 msa	3,222.06 msa	108,125.03 msa	OK
150	93.4	143.6	827.05 msa	3,724.98 msa	176,697.59 msa	OK
160	87.7	139.1	1,057.25 msa	4,305.32 msa	286,833.53 msa	OK
170	82.4	134.8	1,347.22 msa	4,974.21 msa	462,341.05 msa	OK
180	77.8	130.5	1,681.51 msa	5,744.19 msa	739,820.98 msa	OK
190	74.2	126.5	2,024.38 msa	6,629.33 msa	1,175,075.16 msa	OK
200	70.7	122.6	2,438.16 msa	7,645.42 msa	1,852,490.71 msa	OK
210	67.4	118.8	2,935.99 msa	8,810.11 msa	2,898,674.29 msa	OK
220	64.3	115.2	3,533.20 msa	10,143.14 msa	4,502,109.69 msa	OK
230	61.3	111.7	4,247.62 msa	11,666.52 msa	6,941,290.36 msa	OK
240	58.5	108.3	5,099.87 msa	13,404.77 msa	10,624,692.23 msa	OK
250	55.9	105.0	6,113.75 msa	15,385.12 msa	16,147,175.89 msa	OK
260	53.3	101.9	7,316.61 msa	17,637.81 msa	24,369,035.83 msa	OK
270	51.0	98.9	8,739.78 msa	20,196.35 msa	36,526,069.18 msa	OK
280	48.7	96.0	10,419.04 msa	23,097.79 msa	54,381,869.42 msa	OK
290	46.6	93.3	12,395.15 msa	26,383.08 msa	80,437,256.95 msa	OK
300	44.6	90.6	14,714.33 msa	30,097.35 msa	118,216,578.82 msa	OK

Bituminous (mm)	et	ev	Fatigue life	Rutting life	CTB life	Result
310	42.7	88.0	17,428.91 msa	34,290.34 msa	172,656,848.00 msa	**OK**
320	40.9	85.6	20,597.96 msa	39,016.72 msa	250,633,724.67 msa	**OK**
330	39.2	83.2	24,287.94 msa	44,336.55 msa	361,668,633.18 msa	**OK**
340	37.6	80.9	28,573.46 msa	50,315.67 msa	518,874,432.25 msa	**OK**
350	36.1	78.7	33,538.02 msa	57,026.24 msa	740,213,717.23 msa	**OK**

10. Design summary and recommendations

All checks are satisfied for the pavement composition: Bituminous layers 100 mm + Aggregate interlayer 100 mm + Cement treated base 180 mm + Cement treated sub-base 250 mm.

• Surface course: SMA (modified bitumen or VG40), GGRB (crumb rubber modified bitumen) or BC with modified bitumen (Table 9.1).

• Binder / base course: DBM with VG40 bitumen (viscosity >= 3600 Poise at 60 deg C).

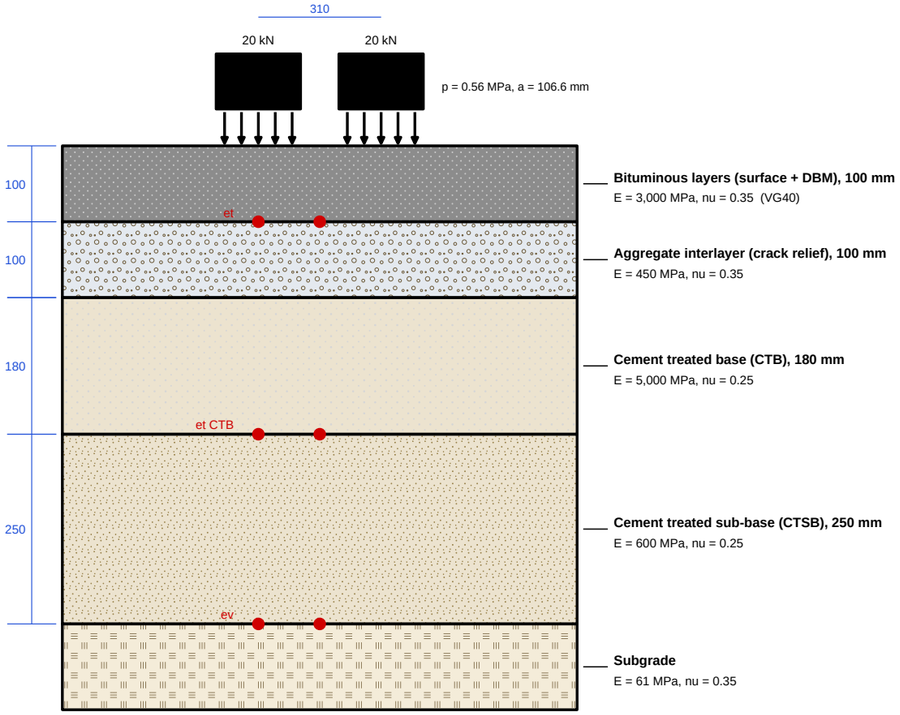
• Bottom DBM: rich bottom mix designed for Va = 3 % and Vbe = 11.5 % (compacted to 4 % or lower in-place air voids for a two-layer DBM, 4.5 % for a single layer).

• Granular sub-base with drainage and filter layers extended over the full formation width (Cl. 7.2.1).

• Subgrade: top 500 mm compacted to 97 % of MDD (heavy compaction), effective CBR 7.0 %.

Report generated 31 Oct 2026.

PAVEMENT COMPOSITION AND CRITICAL LOCATIONS

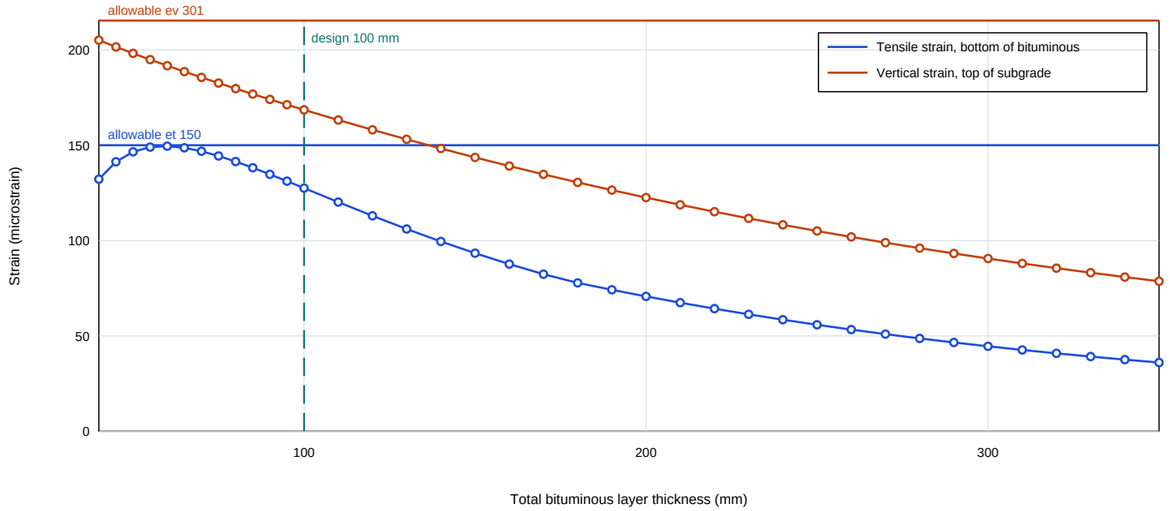


Thicknesses to scale vertically; subgrade semi-infinite. Red dots: critical strain locations (Table 3.1).

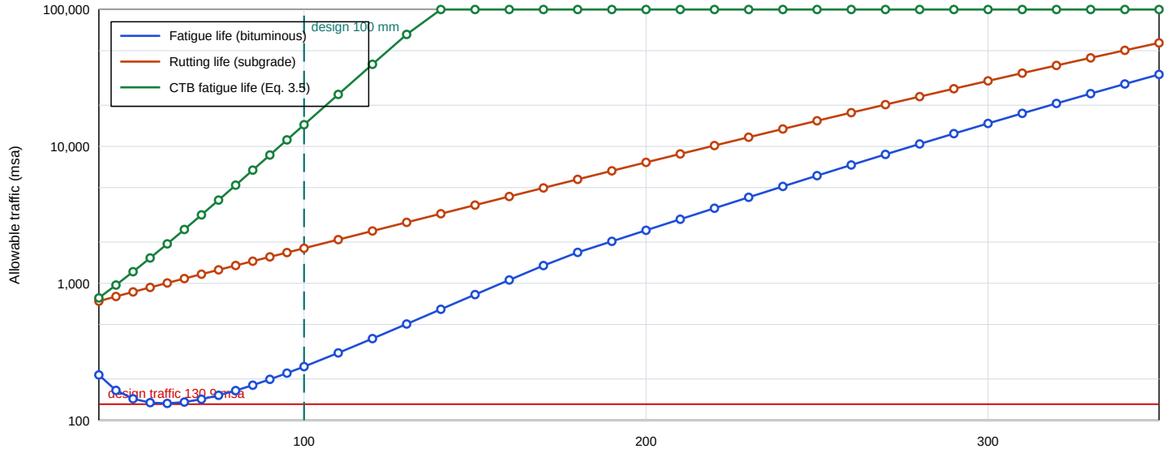
TYPICAL CROSS SECTION (SCHEMATIC)

Dual carriageway - two lanes each way - layer thicknesses exaggerated; total pavement 630 mm.

STRAINS vs BITUMINOUS THICKNESS



LIFE vs BITUMINOUS THICKNESS



DESIGN SUMMARY (IRC:37-2018)

Design traffic	**130.9 msa (90 % reliability)**
Effective subgrade modulus	**61.1 MPa (CBR 7.0 %)**
Composition	**Bituminous + aggregate interlayer + CTB + CTSB**
Layers (mm)	**Bituminous layers 100 + Aggregate interlayer 100 + Cement treated base**
Total pavement thickness	**630 mm**
Bituminous layer modulus	**3,000 MPa (VG40)**
Tensile strain bottom of bituminous	**127.5 / 150.0 allowable**
Vertical strain top of subgrade	**168.6 / 300.6 allowable**
Fatigue life / rutting life	**246.3 / 1,802.9 msa**
CTB tensile strain (0.80 MPa) / life	**44.3 / 14,400.8 msa**
CTB cumulative fatigue damage	**0.788**
Least bituminous thickness (other layers as given)	**100 mm**

Result: **ALL CHECKS SATISFIED**

NOTES

1. All dimensions in mm.
2. Materials and workmanship to MoRTH Specifications (5th rev.).
3. Bottom DBM: rich bottom mix, design air voids as adopted for fatigue.
4. GSB extended full width with drainage and filter layers (Cl. 7.2.1).

IRC 37 example check

Flexible pavement 630 mm ·

Designed: - Checked: -

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