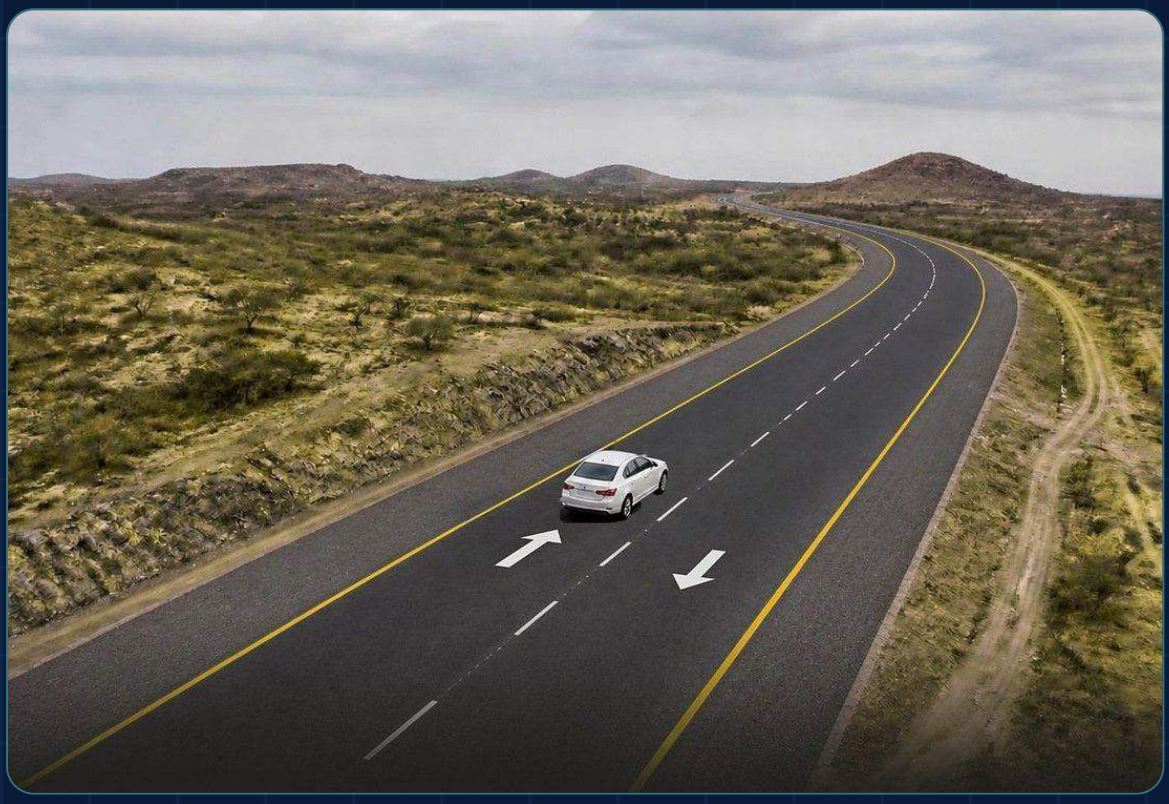
ENGINEERING REPORT

Flexible Pavement Design Report

Based on Austroads Guide to Pavement Technology Part 2: Pavement Structural Design (AGPT02-26)



Sample Project

PREPARED & SUBMITTED BY

SP Consultant

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Sample report: illustrative data, not for design use

EXECUTIVE SUMMARY

The proposed Sample Project (Road 1) will form an important regional transport link within and around the project area. The road traverses predominantly rural and sparsely developed areas, providing connectivity between local communities and supporting the movement of people, goods and commercial traffic. The project corridor forms part of the wider regional road network that connects inland areas with the national highway system and with important trade and economic centres.

The pavement has been designed in accordance with Austroads Guide to Pavement Technology Part 2: Pavement Structural Design (AGPT02-26). The design of the pavement structure includes selecting materials of adequate strength and placing them at the proper thickness, so that the pavement carries the anticipated traffic loading over its design period without structural distress.

Design basis. The pavement has been designed with the two procedures of the Austroads Guide: the empirical design chart (Figure 8.4) for granular pavements with a thin bituminous surfacing, which gives the cover of granular material needed over the subgrade; and the mechanistic-empirical procedure (Section 8.2) for pavements with asphalt, cemented or lightly bound layers, in which the critical strains under the standard axle are compared with the allowable load repetitions for asphalt fatigue, cemented fatigue and subgrade rutting. Five pavement options are designed for the same traffic, subgrade and reliability and compared on thickness, construction cost and whole-of-life cost.

For the design traffic of 4.68×10^7 ESA and a subgrade design CBR of 20%, the Austroads Guide allows several pavement types. The following options have been designed for the same traffic, subgrade and reliability:

- **1. Sprayed seal + granular (Step 2, empirical)**: Seal + 190 Crushed rock base + 100 Crushed rock upper subbase — 290 mm total; passes.
- **2. Seal + lightly bound cemented base**: Seal + 290 lightly bound + 150 granular — 440 mm total; passes.
- **3. Asphalt over granular**: 235 asphalt + 300 granular — 535 mm total; passes.
- **4. Full-depth asphalt**: 240 asphalt on the subgrade — 240 mm total; passes, ranked first.
- **5. Asphalt + cemented subbase**: 190 asphalt + 200 cemented (E 4000, K 233, presumptive, Eq 48) + 150 granular — 540 mm total; passes.

The preferred option is set out below; part 4 of this report compares the options in detail.

The pavement entered in Step 3 (Option 3, 50 + 100 + 300 mm) does not pass the mechanistic-empirical check (governing check asphalt fatigue (16.12)).

Of the options designed for the same traffic and subgrade (part 4.3 of this report), the best-ranked pavement is recommended:

Option	Pavement (mm)	Total (mm)
4. Full-depth asphalt	240 asphalt on the subgrade	240

Design traffic 4.68×10^7 ESA; subgrade design CBR 20%; project reliability 95%.

The key plan and location map are included as Annexure A, the design calculations by Austroads AGPT02-26 in Annexure B, typical cross sections in Annexure C and the soil investigation results of CBR in Annexure D of this report.

1. INTRODUCTION

1.1 General

The proposed Sample Project (Road 1) will form an important regional transport link within and around the project area. The road traverses predominantly rural and sparsely developed areas, providing connectivity between local communities and supporting the movement of people, goods and commercial traffic. The project corridor forms part of the wider regional road network that connects inland areas with the national highway system and with important trade and economic centres.

The development of the Sample Project is expected to improve regional accessibility, reduce travel times and vehicle operating costs, and enhance the movement of goods and passengers, contributing to the socio-economic development of the surrounding areas. The project also forms part of the wider improvement of road infrastructure, supporting connectivity with major routes and access to markets, services and other economic centres.

The proposed road generally follows the existing transport corridor, with improvements and realignments introduced where required to meet the applicable highway standards, improve road geometry, enhance safety and provide an appropriate level of service for the anticipated traffic. The road is expected to carry a significant share of heavy commercial vehicles, many of them loaded close to or above the legal axle load limits, so the axle loads of the heavy vehicles govern the pavement design.

The pavement design has been developed in accordance with the Austroads Guide to Pavement Technology Part 2: Pavement Structural Design (AGPT02-26), considering the projected traffic and its axle loads, the strength and moisture condition of the subgrade, the locally available construction materials, the climate and drainage of the project area, and the construction and maintenance capability expected for the project. The objective is a pavement that carries the design traffic over its design period with an acceptable level of serviceability, at the lowest whole-of-life cost.

The key plan and location map of the project road are provided as Annexure A.

1.2 Design Philosophy

The pavement has been designed in accordance with the Austroads Guide to Pavement Technology Part 2: Pavement Structural Design (AGPT02-26). The guide designs a flexible pavement so that, over the design period, the traffic loading does not cause structural failure of any layer or excessive deformation of the subgrade. Two design procedures are used, depending on the pavement type:

• **Granular pavements with thin bituminous surfacing — empirical design (Figure 8.4).** The design chart is based on the performance of granular pavements in service. It gives the total cover of granular material needed over a subgrade of a given design CBR for the design traffic, and the cover needed over each weaker layer. The surfacing carries no structural value; the pavement relies on well-compacted, high-quality crushed rock.

• **Pavements with asphalt, cemented or lightly bound layers — mechanistic-empirical design (Section 8.2).** The pavement is modelled as a system of elastic layers on the subgrade under the standard axle. The critical strains are calculated at the bottom of the asphalt (fatigue cracking), at the bottom of cemented layers (fatigue cracking) and at the top of the subgrade (permanent deformation, rutting). For each damage mode the allowable number of load repetitions is found from the performance relationships of the guide (for example Equation 25 for asphalt fatigue and Equations 47 and 48 for cemented materials), and the cumulative damage from the design traffic must not exceed 1.0. Cracked cemented layers are analysed in two phases: before cracking and in the post-cracking phase as granular material.

The design traffic is derived from the heavy vehicle axle groups and their loads (Chapter 7). For the mechanistic check each damage mode uses its own load-damage exponent, so the design traffic is expressed in the equivalent repetitions of the standard axle for that mode. The project reliability is applied through reliability factors on the asphalt and cemented fatigue relationships. Minimum layer thicknesses and the construction lifts of asphalt (Table 6.11) are respected.

Because many pavement types can carry the same traffic, the tool designs five options for the same traffic, subgrade and reliability — a granular pavement, a lightly bound base, asphalt over granular, full-depth asphalt and asphalt over a cemented subbase — and compares them on thickness, cost and whole-of-life cost. The choice between them also considers the materials available, the climate and drainage, the construction capability and the traffic risk (Chapters 3 and 10). The recommended pavement is set out in part 4.4 of this report.

2. DESIGN TRAFFIC

The traffic loading for pavement design is expressed as the cumulative number of heavy vehicle axle groups and Equivalent Standard Axles (ESA) in the design lane over the design period, derived in accordance with Chapter 7 of the guide.

2.1 Heavy Vehicle Traffic

The heavy vehicles and the loads on their axle groups adopted for the design are listed below. The ESA of each axle group is (load / standard load)^4.

#	Vehicle	Per day (two-way)	Axle groups (load → ESA)	ESA / vehicle
1	Class 9 - Six axle articulated AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029	164	SAST 53.4 → 1.029 TADT 186.8 → 3.668 TRDT 329.2 → 10.700	15.397
2	Class 8 - Five axle articulated AASHTO Truck Type 2: 125/day in 2026, grown to 2029	137	SAST 57.8 → 1.417 TADT 213.5 → 6.257 TADT 213.5 → 6.257	13.932
3	Class 8 - Five axle articulated AASHTO Truck Type 3: 125/day in 2026, grown to 2029	137	SAST 57.8 → 1.417 TADT 115.7 → 0.539 TADT 115.7 → 0.539	2.494

2.2 Traffic Parameters

Parameter	Value
Design period P	20 years
Annual heavy vehicle growth R	3%
Direction factor DF	1
Lane distribution factor LDF	1
Cumulative growth factor CGF (Equation 31)	26.87

Direction factor

A direction factor of 1.0 has been adopted: the heavy vehicle numbers used are those of the design direction only.

Lane distribution factor

All heavy vehicles travelling in the design direction use the design lane (lane distribution factor 1.0), as on a road with one lane in each direction.

2.3 Design Traffic

Quantity	Value
Heavy vehicles per day in the design lane, first year (Equation 30)	438.0
Cumulative heavy vehicles in the design lane N_{DT} (Equation 32)	4.30×10^6
Cumulative heavy vehicle axle groups $N_{DT,HVAG}$ (Equation 35)	1.29×10^7
ESA per heavy vehicle axle group	3.634
Design traffic (DESA)	**4.68×10^7 ESA**

2.4 Axle Loads and Their Effect on the Pavement

The axle group loads of the heavy vehicles are compared below with the legal axle load limits of the National Highway Authority (NHA, NHSO 2000 regime: front single axle 5.5 t, single axle 12 t, tandem 22 t, tridem 31 t). The last two columns give the equivalent standard axles (ESA) of each axle group with the load as entered and with the load capped at the legal limit.

Vehicle	Axle group	Load (t)	Legal limit (t)	Load / limit	Status	ESA as entered	ESA at the legal limit
Class 9 - Six axle articulated (AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029)	SAST — single axle, single tyres	5.4	5.5	99%	within	1.029	1.029
Class 9 - Six axle articulated (AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029)	TADT — tandem axle, dual tyres	19.1	22.0	87%	within	3.668	3.668
Class 9 - Six axle articulated (AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029)	TRDT — triaxle, dual tyres	33.6	31.0	108%	over by 8%	10.700	7.785
Class 8 - Five axle articulated (AASHTO Truck Type 2: 125/day in 2026, grown to 2029)	SAST — single axle, single tyres	5.9	5.5	107%	over by 7%	1.417	1.073
Class 8 - Five axle articulated (AASHTO Truck Type 2: 125/day in 2026, grown to 2029)	TADT — tandem axle, dual tyres	21.8	22.0	99%	within	6.257	6.257
Class 8 - Five axle articulated (AASHTO Truck Type 2: 125/day in 2026, grown to 2029)	TADT — tandem axle, dual tyres	21.8	22.0	99%	within	6.257	6.257
Class 8 - Five axle articulated (AASHTO Truck Type 3: 125/day in 2026, grown to 2029)	SAST — single axle, single tyres	5.9	5.5	107%	over by 7%	1.417	1.073
Class 8 - Five axle articulated (AASHTO Truck Type 3: 125/day in 2026, grown to 2029)	TADT — tandem axle, dual tyres	11.8	22.0	54%	within	0.539	0.539
Class 8 - Five axle articulated (AASHTO Truck Type 3: 125/day in 2026, grown to 2029)	TADT — tandem axle, dual tyres	11.8	22.0	54%	within	0.539	0.539

The heaviest axle group is the TRDT of the Class 9 - Six axle articulated at **33.6 t**, 8% above the legal limit of 31.0 t. **33% of the axle group passes are above the legal limits.**

The damage of an axle group rises with about the fourth power of its load (Equation 37, the fourth power law of Section 7.6.2): a group 10% over the limit does about 1.46 times the damage of a legal one, and 20% over about 2.07 times. With the loads as entered the traffic gives **4,775.4 ESA per day** (two-way), against 4,202.9 ESA per day if every axle group carried no more than its legal limit: **overloading increases the design traffic by 14%**. In the mechanistic-empirical design (Section 8.2) the full axle load distribution is analysed, so the heavy groups weigh as heavily in the asphalt fatigue and subgrade checks.

Share of the ESA by vehicle: Class 9 - Six axle articulated (AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029) 53%, Class 8 - Five axle articulated (AASHTO Truck Type 2: 125/day in 2026, grown to 2029) 40%, Class 8 - Five axle articulated (AASHTO Truck Type 3: 125/day in 2026, grown to 2029) 7%.

Axle load survey data should be used where available, and enforcement of the legal limits protects the pavement.

3. PAVEMENT DESIGN PARAMETERS

The design parameters adopted for the project road are presented in the following sub-sections. The design traffic is presented in part 2 of this report.

3.1 Design Period

A design period of **20 years** has been adopted (Table 7.2 gives typical design periods). The pavement is designed to carry the cumulative traffic of this period without major structural rehabilitation.

3.2 Subgrade Design CBR

The subgrade strength is characterised by its design California Bearing Ratio (CBR). A subgrade design CBR of **20%** has been adopted. The soil investigation results are given in Annexure D.

3.3 Project Reliability

A project reliability of **95%** has been adopted for the mechanistic-empirical design; the corresponding asphalt fatigue reliability factor is RF = 6. The reliability reflects the importance of the road and the consequence of early distress.

3.4 Pavement Materials

Layer	Thickness (mm)	Design modulus E (MPa)	Notes
Asphalt wearing course (14 mm mix)	50	3150	Class 320, 14 mm mix, V_b 11%
Asphalt base course (20 mm mix)	100	3470	Class 320, 20 mm mix, V_b 11%
Granular (crushed rock)	300	–	normal standard, sublayered

The material specifications of each option are given in Annexure B.

4. COMPUTATION OF PAVEMENT THICKNESS

The pavement thickness is determined for each option with the design parameters of parts 2 and 3 of this report. The detailed calculations are given in Annexure B.

4.1 Empirical Design (Figure 8.4)

For a granular pavement with a thin bituminous surfacing, Figure 8.4 gives the cover of granular material required over the subgrade of design CBR 20% for the design traffic of 4.68×10^7 ESA:

Layer	Design CBR (%)	Thickness (mm)
Crushed rock base	80	190
Crushed rock upper subbase	30	100
Total cover over the subgrade		**290**

Result: **PASSES**.

4.2 Mechanistic-Empirical Design (Section 8.2)

The selected pavement (Option 3 — Asphalt over granular) has been analysed with the layered elastic model under the standard axle. The cumulative damage of each damage mode is compared with 1.0:

Pavement layer	Thickness (mm)
Asphalt wearing course (14 mm mix)	50
Asphalt base course (20 mm mix)	100
Granular base / subbase (crushed rock)	300

Governing check: asphalt fatigue (16.12) — result **DOES NOT PASS**.

4.3 Comparison of Pavement Options

All options were designed for the same traffic, subgrade and reliability. Options that fail, are not recommended or are qualified are not ranked; the rank is a screening and the choice also considers materials, construction and maintenance.

Option	Pavement (mm)	Asphalt (mm)	Total (mm)	Result	Rank
1. Sprayed seal + granular (Step 2, empirical)	Seal + 190 Crushed rock base + 100 Crushed rock upper subbase	0	290	**PASSES**	2
2. Seal + lightly bound cemented base	Seal + 290 lightly bound + 150 granular	0	440	**PASSES**	3
3. Asphalt over granular	235 asphalt + 300 granular	235	535	**PASSES**	4
4. Full-depth asphalt	240 asphalt on the subgrade	240	240	**PASSES**	★ 1
5. Asphalt + cemented subbase	190 asphalt + 200 cemented (E 4000, K 233, presumptive, Eq 48) + 150 granular	190	540	**PASSES**	5

4.4 Recommended Pavement

The pavement entered in Step 3 (Option 3, 50 + 100 + 300 mm) does not pass the mechanistic-empirical check (governing check asphalt fatigue (16.12)).

Of the options designed for the same traffic and subgrade (part 4.3 of this report), the best-ranked pavement is recommended:

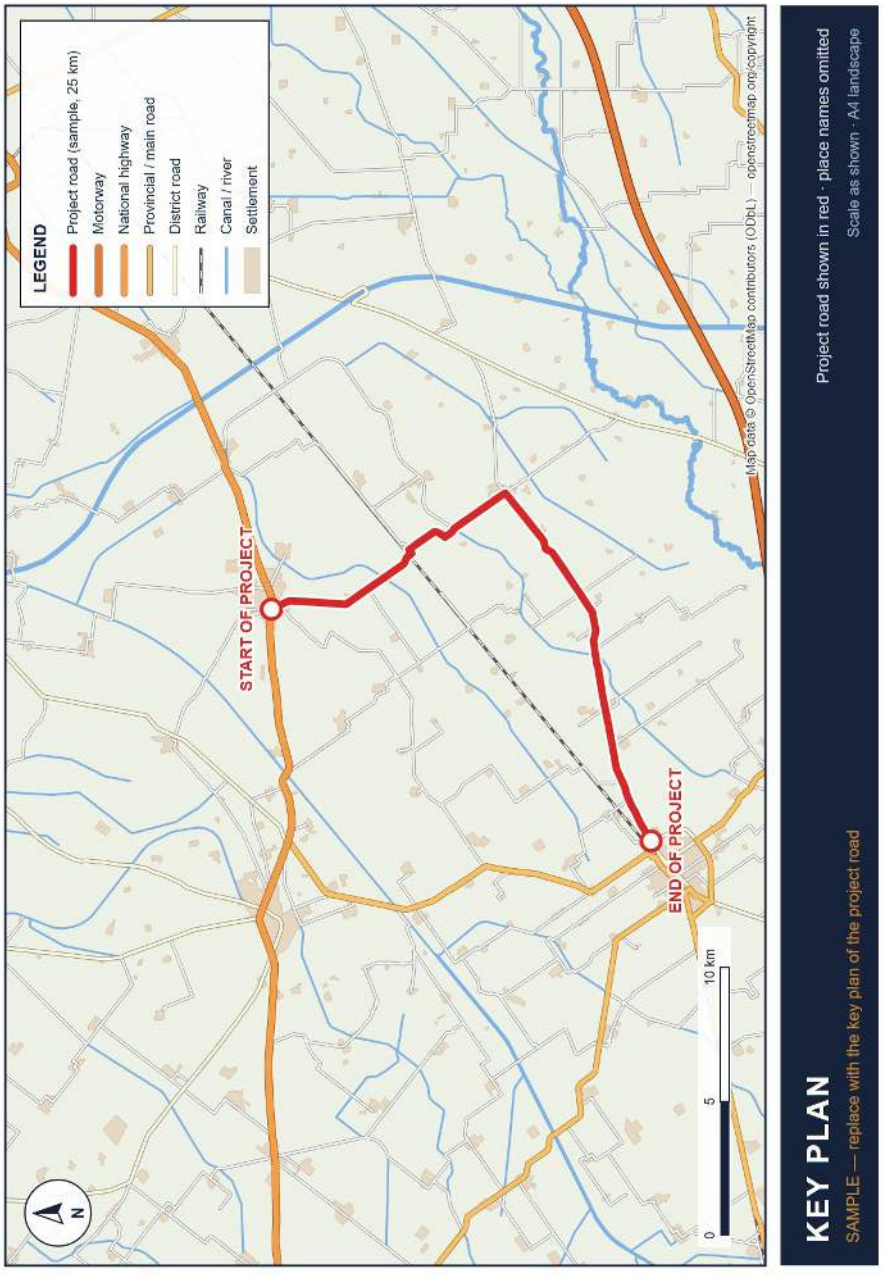
Option	Pavement (mm)	Total (mm)
4. Full-depth asphalt	240 asphalt on the subgrade	240

Design traffic 4.68×10^7 ESA; subgrade design CBR 20%; project reliability 95%.

The pavement layers are drawn to scale in Annexure C (Typical Cross Sections), and the detailed design calculations are given in Annexure B.

ANNEXURE – A (KEY PLAN AND LOCATION MAP)

Referred to in: Executive Summary, 1.1 General.



Sample key plan — insert the actual key plan and location map of the project road to replace this sample (upload it in the report form under Annexure A; use + Add plan for more). Map data © OpenStreetMap contributors (ODbL).

ANNEXURE – B (DESIGN CALCULATIONS BY AUSTROADS AGPT02-26)

Referred to in: Executive Summary, 3.4 Pavement Materials, 4. Computation of Pavement Thickness, 4.4 Recommended Pavement.

Full printout of the Austroads Flexible Pavement Design tool, corresponding to the design summarised above.

Report information

Design guide	Austroads AGPT02-26, Guide to Pavement Technology Part 2: Pavement Structural Design (Edition 5.2)
Tool build	APD 2026-10-19 (audit F01-F10 repairs)
Input checksum	61bc587b (FNV-1a of all inputs; any change to the inputs changes it)
Traffic load data	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.
Generated	11/5/2026, 12:17:02 PM
Review status	**Not reviewed.** Calculation output only — it must be checked and approved by a qualified pavement engineer before use.

1. Design traffic

Design period	20 years	Growth rate	3%
Direction factor	1	Lane distribution factor	1

Heavy vehicles and axle loads

#	Vehicle	Description	Per day (two-way)	Axle groups (kN → ESA)	ESA / vehicle
1	Class 9 - Six axle articulated	AASHTO Truck Type 1 (Composite): 150/day in 2026, grown to 2029	164	SAST 53.4 → 1.029 TADT 186.8 → 3.668 TRDT 329.2 → 10.700	15.397
2	Class 8 - Five axle articulated	AASHTO Truck Type 2: 125/day in 2026, grown to 2029	137	SAST 57.8 → 1.417 TADT 213.5 → 6.257 TADT 213.5 → 6.257	13.932
3	Class 8 - Five axle articulated	AASHTO Truck Type 3: 125/day in 2026, grown to 2029	137	SAST 57.8 → 1.417 TADT 115.7 → 0.539 TADT 115.7 → 0.539	2.494

Heavy vehicles / day, two-way	Axle groups per HV, N_{HVAG}	ESA per axle group
438	**3.00**	**3.634**

ESA per heavy vehicle (average damage factor)	Cumulative HV, design lane	Design traffic DESA
10.903	**4.30×10^6**	**4.68×10^7 ESA**

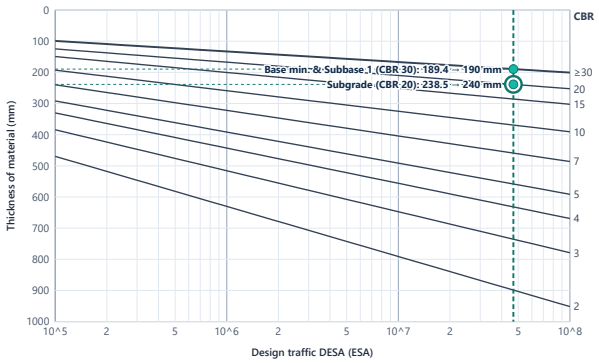
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n (Eq 30)   = 438.0 HV/day × DF 1 × LDF 1 = 438.0 HV/day in the design lane
CGF (Eq 31) = ((1 + 0.01×3)^20 − 1) / (0.01×3) = 26.87
N_DT (Eq 32) = 365 × 26.87 × 438.0 = 4.30E+06 heavy vehicles
N_DT,HVAG (Eq 35) = 4.30E+06 × 3.000 = 1.29E+07 axle groups
Damage factor: ESA of an axle group = (load / standard load)^4 (Eq 37); per vehicle = sum of
its groups; average = Σ(HV/day × ESA/vehicle) ÷ Σ HV/day = 4,775.4 ÷ 438.0 = 10.903 ESA per
heavy vehicle
DESA (Eq 38) = 3.6343 ESA/HVAG × 1.29E+07 = 4.68E+07 ESA   (= 10.903 average damage factor ×
4.30E+06 heavy vehicles)
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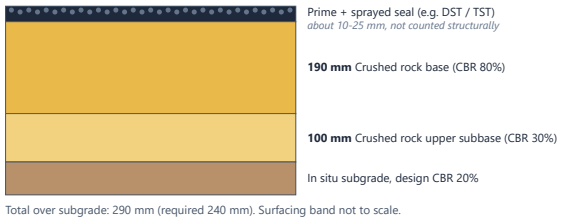
2. Option 1 — Sprayed seal + granular, empirical design (Figure 8.4)

Subgrade design CBR 20% · design traffic 4.68×10^7 ESA · rounding: Round up to 10 mm · minimum layer 100 mm

Layer	Design CBR (%)	Thickness (mm)	Depth to bottom (mm)	Cover needed (mm)	Check
Sprayed seal					
Crushed rock base	80	**190**	190	190 (min. base)	OK
Crushed rock upper subbase	30	**100**	290	190	OK
In situ subgrade	20		290	240	OK

Cover over the subgrade: 238.5 mm calculated from the chart equation, 240 mm adopted after rounding up. Every check is made against the calculated (unrounded) value, tolerance 0.5 mm.





Total over subgrade: 290 mm (required 240 mm). Surfacing band not to scale.

Design OK — every material has enough cover.

Material specifications — Option 1

Property	Requirement	Test	Source
Sprayed seal (wearing surface, no structural value — AGPT02 8.3.2)			
Prime	Cutback (AMC0/AMC1) or bitumen-emulsion prime on the dry, swept, compacted base	AS 2157	typical – confirm with Part 4K
Binder	Class 170 bitumen; polymer-modified binder on heavy traffic, curves and intersections	AS 2008	typical – confirm with Part 4K
Aggregate size	Double/triple seal, e.g. 14 mm then 7 mm (or 10 mm then 5 mm); single-sized	AS 1141.11	typical – confirm with Part 4K
Particle shape	Crushed, cubical (angular), clean and pre-coated; flakiness index ≤ 25%	AS 1141.15	typical – confirm with Part 4K
Hardness	Los Angeles abrasion loss ≤ 30%	AS 1141.23	typical – confirm with Part 4K
Skid resistance	Polished aggregate friction value ≥ 44 (higher at high-stress sites)	AS 1141.40	typical – confirm with Part 4K
Unbound granular base (crushed rock)			
Quality class	Normal-standard crushed rock (as commonly used by road agencies) or high-standard crushed rock: sound, durable igneous/metamorphic rock, highly processed to tight tolerances on durability, hardness, grading and Atterberg limits, placed to very high density and moisture standards	—	**AGPT02 6.2.3, Table 6.3**
Strength	Soaked CBR ≥ 80% (base quality)	AS 1289.6.1.1	**AGPT02 8.3.2**
Minimum thickness	Base thickness ≥ cover over CBR 30 material (Figure 8.4 / 12.2); at least 100 mm of crushed rock base where the asphalt surfacing is under 100 mm thick	—	**AGPT02 8.3.2, 12.6.1, 12.8.2**
Source	100% crushed quarried hard rock; angular particles with fractured faces	AS 1141.18	typical – confirm with Part 4A
Nominal size	20 mm (all passing 26.5 mm)	AS 1141.11	typical – confirm with Part 4A
Grading (% passing)	26.5 mm 100 · 19 mm 95–100 · 13.2 mm 77–93 · 9.5 mm 63–83 · 4.75 mm 44–64 · 2.36 mm 30–48 · 0.425 mm 13–21 · 0.075 mm 5–11	AS 1141.11	typical – confirm with Part 4A
Particle shape	Flakiness index ≤ 35%	AS 1141.15	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 6; linear shrinkage ≤ 3%	AS 1289.3.3.1 / 3.4.1	typical – confirm with Part 4A

Property	Requirement	Test	Source
Hardness	Los Angeles abrasion loss ≤ 35%; wet strength (10% fines) ≥ 100 kN, wet/dry variation ≤ 35%	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 98% of modified MDD, at or just below OMC; dry back before sealing	AS 1289.5.2.1	typical – confirm with Part 4A
Unbound granular subbase (crushed rock or natural gravel)			
Strength	Upper subbase soaked CBR ≥ 30%; every subbase at least the design CBR used for its cover (Figure 8.4)	AS 1289.6.1.1	**AGPT02 8.3.2**
Source	Crushed rock, or screened/crushed natural gravel; angular to sub-angular particles preferred	AS 1141.18	typical – confirm with Part 4A
Nominal size	20–40 mm (all passing 53 mm); not more than half the layer thickness	AS 1141.11	typical – confirm with Part 4A
Grading	Continuous, well graded; 0.075 mm passing 4–14%	AS 1141.11	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 10 (upper subbase), ≤ 12 (lower subbase)	AS 1289.3.3.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 40%; wet strength (10% fines) ≥ 50 kN	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 95% of modified MDD	AS 1289.5.2.1	typical – confirm with Part 4A
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Water-bound macadam (WBM). *WBM is also an angular crushed-stone base, but it is not an Austroads material. If you specify WBM (NHA / MORTH practice), use that specification and enter its CBR above; the base must still reach CBR 80%.*

Sources: *rows marked* ***AGPT02*** *are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B (asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.*

3. Selected Step 3 design (as entered)

3.1 Selected design — Option 3 — Asphalt over granular (mechanistic-empirical, Section 8.2)

Reliability 95% (asphalt RF 6, SF 6) · subgrade CBR 20% · design traffic 4.68 × 10^7 ESA · granular 300 mm (normal standard) · subgrade ν 0.45

Asphalt layer	Thickness (mm)	Design E (MPa)	V_b (%)	Binder, mix	Source of E
Asphalt wearing course (14 mm mix)	50	3150	11	Class 320, 14 mm	Appendix K example
Asphalt base course (20 mm mix)	100	3470	11	Class 320, 20 mm	Appendix K example

Fatigue: Equation 25 (conventional binders, Section 6.7.10).

Option 3 — Asphalt over granular

✗ **Not adequate** — governing: asphalt fatigue (Asphalt base course (20 mm mix)) (16.124 > 1). Increase the asphalt thickness or use **Find minimum thickness**.

Total asphalt **150 mm**

Asphalt fatigue (design / allowable) **16.124**

Subgrade rutting (design / allowable) **0.001**

Result **NOT OK**

Reliability / RF **95% / 6**

Critical strains and damage

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Asphalt fatigue – bottom of Asphalt wearing course (14 mm mix)	50	5.9	compression	by load (TLD)	TLD	0.000	✓ OK
Asphalt fatigue – bottom of Asphalt base course (20 mm mix)	150	187.7	182.6	by load (TLD)	TLD	16.124	✗ > 1
Subgrade rutting – top of in situ subgrade	450	255.6	–	7.53 × 10^{10} ESA	4.68 × 10^7 ESA	0.001	✓ OK

Fatigue damage by axle group type

Layer	SAST	TADT	TRDT	Total
Asphalt wearing course (14 mm mix)	0.0000	0.0000	0.0000	**0.000**
Asphalt base course (20 mm mix)	1.3799	8.3742	6.3697	**16.124**

Pavement layers

Layer	Thickness (mm)	Design modulus E_v (MPa)	Model
Asphalt wearing course (14 mm mix)	50	3,150	isotropic, ν 0.4
Asphalt base course (20 mm mix)	100	3,470	isotropic, ν 0.4
Granular base + subbase (normal standard)	300	179 → 155	5 analysis sublayers, anisotropic (E_h = E_v/2), ν 0.35
Subgrade	semi-infinite	150	anisotropic (E_h = E_v/2), ν 0.45

Asphalt: structural thickness and construction lifts

Asphalt layer	Structural thickness (mm)	Mix	Construction lifts	Lift range (Table 6.11 / 12.1)
Asphalt wearing course (14 mm mix)	50	14 mm	1 × 50 mm (auto)	45–70 mm OK
Asphalt base course (20 mm mix)	100	20 mm	1 × 100 mm (auto)	60–100 mm OK

▼ Equations and material sources used

Check	Equation / rule (AGPT02-26)	Inputs and source
Asphalt fatigue	Equation 25, N = (SF/RF) × [6918 (0.856 V_b + 1.08) / ($E^{0.36}$ με)]^5, SF 6, RF 6 (Table 6.17)	Asphalt wearing course (14 mm mix): E 3150 MPa, Appendix K example, Class 320; Asphalt base course (20 mm mix): E 3470 MPa, Appendix K example, Class 320
Subgrade rutting	Equation 3, N = (9150 / με)^7; in situ and improved subgrade	E_v = 10 × CBR, max 150 MPa (Section 5.6); in situ ν 0.45
Granular modulus	Top sublayer = min(Table 6.4, Equation 42); 5 sublayers (Section 8.2.3)	Normal standard crushed rock
Traffic load	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.	

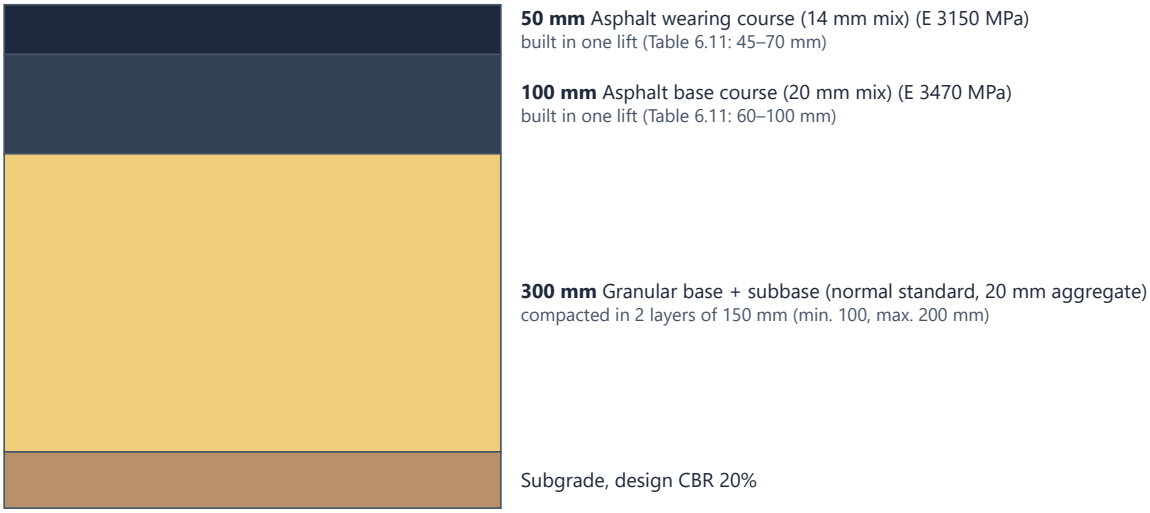
▼ Analysis model, every sublayer (for checking, e.g. in CIRCLY)

Layer	Thickness (mm)	E_v (MPa)	E_h (MPa)	ν
Asphalt wearing course (14 mm mix)	50	3,150	3,150	0.4
Asphalt base course (20 mm mix)	100	3,470	3,470	0.4
Granular – analysis sublayer 1 of 5	60	179	90	0.35
Granular – analysis sublayer 2 of 5	60	173	86	0.35
Granular – analysis sublayer 3 of 5	60	167	83	0.35
Granular – analysis sublayer 4 of 5	60	161	81	0.35
Granular – analysis sublayer 5 of 5	60	155	78	0.35
Subgrade	semi-infinite	150	75	0.45

*Granular and improved subgrade layers are split into 5 equal **analysis sublayers** only for the calculation (Sections 8.2.2–8.2.3): their stiffness changes with depth, so each sublayer gets its own modulus. They are not construction layers — build the base and subbase you specify in normal compaction lifts.*

```
Subgrade: Ev = min(10 × CBR 20, 150) = 150 MPa, Eh = Ev/2, v = 0.45 (cohesive)
Granular top sublayer: min(Table 6.4 179 MPa [over 150 mm bound, Eeq 3361 MPa], Eq 42 792
MPa) = 179 MPa; 5 sublayers, ratio 1.036
Asphalt fatigue (Eq 25): N = SF/RF × [6918(0.856 Vb + 1.08)/(E^0.36 με)]^5, SF 6, RF 6; axle
groups use the strain of one axle (group load ÷ axles) and allowable ÷ axles
Subgrade rutting: N = (9150/με)^7 ESA
```

Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane. Granular base + subbase 300 mm: built in 2 compaction layers of 150 mm (specification maximum 200 mm per layer, at least 100 mm for 20 mm maximum particle size). Austroads leaves the compaction layer limits to the construction specification (Section 3.7). Subgrade vertical modulus = 10 × CBR, limited to 150 MPa (Section 5.6).



Total asphalt 150 mm, granular 300 mm.

Option 3 — Asphalt over granular: cross-section (to scale).

Material specifications — Option 3

Property	Requirement	Test	Source
Dense-graded asphalt			
Mix size	Dense graded wearing course 7 or 10 mm (light traffic, low speed) or 10 or 14 mm (heavier traffic), 14 mm most common; base / intermediate layers e.g. 20 mm (Table 6.15 lists 10, 14 and 20 mm)	AS 2150	**AGPT02 2.2.4–2.2.5, Table 6.15**
Binder	Class 170 / 320 / 600, multigrade or A10E; the binder and mix size set the laboratory modulus (Table 6.15) used by the design-modulus helper	AS 2008	**AGPT02 Table 6.15**
Modulus test	Indirect tensile modulus at 25 °C, 40 ms rise time, 5% air voids; corrected for in-service air voids, WMAPT and speed; design modulus ≥ 1000 MPa	AS/NZS 2891.13.1	**AGPT02 6.7.5**
Binder volume V_b	Percentage by volume of bitumen, used in the fatigue equation (Equation 25); the guide's worked examples use 11%	—	**AGPT02 6.7.10, App. K**
Bond / waterproofing	Prime or initial seal under the asphalt on granular bases; tack coat between asphalt layers	—	**AGPT02 2.2.4–2.2.5**
Aggregate	Crushed rock, angular; flakiness index ≤ 25%; Los Angeles abrasion ≤ 30%; PAFV ≥ 44 in the wearing course	AS 1141.15 / .23 / .40	typical – confirm with Part 4B
In-place air voids	About 3–7% after compaction	AS/NZS 2891.9.2	typical – confirm with Part 4B
Layer thickness	Compacted layer 2.5–4 × nominal size	AS 2150	typical – confirm with Part 4B
Unbound granular base (crushed rock)			
Quality class	Normal-standard crushed rock (as commonly used by road agencies) or high-standard crushed rock: sound, durable igneous/metamorphic rock, highly processed to tight tolerances on durability, hardness, grading and Atterberg limits, placed to very high density and moisture standards	—	**AGPT02 6.2.3, Table 6.3**
Strength	Soaked CBR ≥ 80% (base quality)	AS 1289.6.1.1	**AGPT02 8.3.2**
Minimum thickness	Base thickness ≥ cover over CBR 30 material (Figure 8.4 / 12.2); at least 100 mm of crushed rock base where the asphalt surfacing is under 100 mm thick	—	**AGPT02 8.3.2, 12.6.1, 12.8.2**
Source	100% crushed quarried hard rock; angular particles with fractured faces	AS 1141.18	typical – confirm with Part 4A
Nominal size	20 mm (all passing 26.5 mm)	AS 1141.11	typical – confirm with Part 4A
Grading (% passing)	26.5 mm 100 · 19 mm 95–100 · 13.2 mm 77–93 · 9.5 mm 63–83 · 4.75 mm 44–64 · 2.36 mm 30–48 · 0.425 mm 13–21 · 0.075 mm 5–11	AS 1141.11	typical – confirm with Part 4A

Property	Requirement	Test	Source
Particle shape	Flakiness index ≤ 35%	AS 1141.15	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 6; linear shrinkage ≤ 3%	AS 1289.3.3.1 / 3.4.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 35%; wet strength (10% fines) ≥ 100 kN, wet/dry variation ≤ 35%	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 98% of modified MDD, at or just below OMC; dry back before sealing	AS 1289.5.2.1	typical – confirm with Part 4A
Unbound granular subbase (crushed rock or natural gravel)			
Strength	Upper subbase soaked CBR ≥ 30%; every subbase at least the design CBR used for its cover (Figure 8.4)	AS 1289.6.1.1	**AGPT02 8.3.2**
Source	Crushed rock, or screened/crushed natural gravel; angular to sub-angular particles preferred	AS 1141.18	typical – confirm with Part 4A
Nominal size	20–40 mm (all passing 53 mm); not more than half the layer thickness	AS 1141.11	typical – confirm with Part 4A
Grading	Continuous, well graded; 0.075 mm passing 4–14%	AS 1141.11	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 10 (upper subbase), ≤ 12 (lower subbase)	AS 1289.3.3.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 40%; wet strength (10% fines) ≥ 50 kN	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 95% of modified MDD	AS 1289.5.2.1	typical – confirm with Part 4A
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Sources: *rows marked* ***AGPT02*** *are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B*

(asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.

4. Alternatives generated by the option comparison

Each alternative was generated for the same traffic, subgrade and reliability. Its thickness is the lowest passing tested candidate (see the note under the comparison); each carries its own applicability checks. These are alternatives, not the selected design above.

4.1 Alternative — Option 2 — Sprayed seal + lightly bound cemented base (mechanistic-empirical, Section 8.2)

Reliability 95% (asphalt RF 6, SF 6) · subgrade CBR 20% · design traffic 4.68×10^7 ESA · granular 150 mm (normal standard) · subgrade ν 0.45

Option 2 — Sprayed seal + lightly bound cemented base

✓ **Pavement OK** — all checks pass. Governing: lightly bound base thickness (Equation 44) (0.972).

Total asphalt	Asphalt fatigue (design / allowable)	Subgrade rutting (design / allowable)	Result
none (seal)	**–**	**0.011**	**OK**

Reliability / RF
95% / 6

Critical strains and damage

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Subgrade rutting – top of in situ subgrade	440	385.5	–	4.25×10^9 ESA	4.68×10^7 ESA	0.011	✓ OK

Lightly bound base checks (Section 8.2.4)

Check	Required	Provided	Check
Minimum base thickness, Equation 44: max[200, 250 + 35 log(DESA/5×10^6) – 0.25(E_{under} − 150)]	283 mm	290 mm	✓ OK
Granular subbase under the base, at least 150 mm	150 mm	150 mm	✓ OK
Top subbase sublayer vertical modulus, at least 150 MPa	150 MPa	158 MPa	✓ OK

E_{under} = 158 MPa (top sublayer of the granular subbase); Equation 44 minimum before the asphalt reduction = 283 mm. No fatigue check of the lightly bound layer (Section 6.6).

Pavement layers

Layer	Thickness (mm)	Design modulus E_v (MPa)	Model
Lightly bound cemented base	290	600	anisotropic ($E_h = E_v/2$), ν 0.35
Granular base + subbase (normal standard)	150	158 → 152	5 analysis sublayers, anisotropic ($E_h = E_v/2$), ν 0.35
Subgrade	semi-infinite	150	anisotropic ($E_h = E_v/2$), ν 0.45

▼ Equations and material sources used

Check	Equation / rule (AGPT02-26)	Inputs and source
Subgrade rutting	Equation 3, $N = (9150 / \mu\varepsilon)^7$; in situ and improved subgrade	E_v = 10 × CBR, max 150 MPa (Section 5.6); in situ ν 0.45
Granular modulus	Top sublayer = min(Table 6.4, Equation 42); 5 sublayers (Section 8.2.3)	Normal standard crushed rock
Lightly bound base	Minimum thickness Equation 44; support ≥ 150 mm at ≥ 150 MPa (Section 8.2.4)	Cracked state, E ≤ 600 MPa, cross-anisotropic $E_h = E_v/2$, ν 0.35 (Section 6.6.1). Table K.36 prints it isotropic, but the guide's K.4 result (827 με, p.288) is reproduced only with $E_h = E_v/2$ (827.5 vs 691.5)
Traffic load	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.	

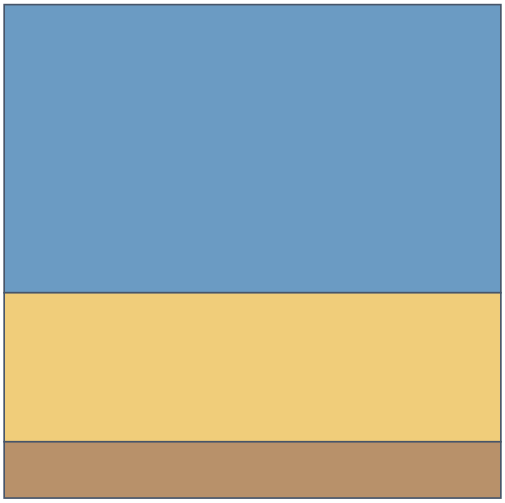
▼ Analysis model, every sublayer (for checking, e.g. in CIRCLY)

Layer	Thickness (mm)	E_v (MPa)	E_h (MPa)	ν
Lightly bound cemented base	290	600	300	0.35
Granular – analysis sublayer 1 of 5	30	158	79	0.35
Granular – analysis sublayer 2 of 5	30	156	78	0.35
Granular – analysis sublayer 3 of 5	30	155	77	0.35
Granular – analysis sublayer 4 of 5	30	153	77	0.35
Granular – analysis sublayer 5 of 5	30	152	76	0.35
Subgrade	semi-infinite	150	75	0.45

*Granular and improved subgrade layers are split into 5 equal **analysis sublayers** only for the calculation (Sections 8.2.2–8.2.3): their stiffness changes with depth, so each sublayer gets its own modulus. They are not construction layers — build the base and subbase you specify in normal compaction lifts.*

```
Subgrade: Ev = min(10 × CBR 20, 150) = 150 MPa, Eh = Ev/2, ν = 0.45 (cohesive)
Granular top sublayer: min(Table 6.4 158 MPa [over 290 mm bound, Eeq 600 MPa], Eq 42 345 MPa)
= 158 MPa; 5 sublayers, ratio 1.010
Lightly bound base (cracked behaviour): Ev = min(600, 4 × support 158 within 240–600) = 600
MPa, Eh = Ev/2, ν 0.35, not sublayered (Sections 6.6.2, 8.2.4)
Asphalt fatigue (Eq 25): N = SF/RF × [6918(0.856 Vb + 1.08)/(E^0.36 με)]^5, SF 6, RF 6; axle
groups use the strain of one axle (group load ÷ axles) and allowable ÷ axles
Subgrade rutting: N = (9150/με)^7 ESA
```

Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane. Granular base + subbase 150 mm: built in one compaction layer (specification maximum 200 mm per layer, at least 100 mm for 20 mm maximum particle size). Austroads leaves the compaction layer limits to the construction specification (Section 3.7). Subgrade vertical modulus = 10 × CBR, limited to 150 MPa (Section 5.6).



Total asphalt 0 mm, granular 150 mm.

Option 2 — Sprayed seal + lightly bound cemented base: cross-section (to scale).

Material specifications — Option 2

Property	Requirement	Test	Source
Sprayed seal (wearing surface, no structural value — AGPT02 8.3.2)			
Prime	Cutback (AMC0/AMC1) or bitumen-emulsion prime on the dry, swept, compacted base	AS 2157	typical – confirm with Part 4K
Binder	Class 170 bitumen; polymer-modified binder on heavy traffic, curves and intersections	AS 2008	typical – confirm with Part 4K
Aggregate size	Double/triple seal, e.g. 14 mm then 7 mm (or 10 mm then 5 mm); single-sized	AS 1141.11	typical – confirm with Part 4K
Particle shape	Crushed, cubical (angular), clean and pre-coated; flakiness index ≤ 25%	AS 1141.15	typical – confirm with Part 4K
Hardness	Los Angeles abrasion loss ≤ 30%	AS 1141.23	typical – confirm with Part 4K
Skid resistance	Polished aggregate friction value ≥ 44 (higher at high-stress sites)	AS 1141.40	typical – confirm with Part 4K
Lightly bound cemented base			
Parent material	Granular material with laboratory soaked CBR ≥ 30% (otherwise it is designed as unbound granular)	AS 1289.6.1.1	**AGPT02 6.6.2**
Strength	28-day UCS 1.0–2.0 MPa, specimens at 100% standard MDD and OMC, moist cured without soaking	AS 5101.4	**AGPT02 6.6.1**
Minimum thickness and support	Thickness ≥ Equation 44 minimum (never below 200 mm); on a subbase ≥ 150 mm with top-sublayer modulus ≥ 150 MPa	—	**AGPT02 8.2.4**
Shrinkage control	Fines < 20% passing 75 µm and plasticity index ≤ 20; slow-setting binders shrink less than GP cement	AS 1141.11 / AS 1289.3.3.1	**AGPT02 6.5**
Binder	About 1–2% GP cement, or a slag / fly-ash blend, by mass	AS 3972	typical – confirm with Part 4D
Construction	Mix in-situ or in a pugmill; compact ≥ 98% of modified MDD within the binder working time	AS 1289.5.2.1	typical – confirm with Part 4D
Curing	Keep moist at least 7 days, or prime / initial seal straight after compaction	—	typical – confirm with Part 4D
Unbound granular subbase (crushed rock or natural gravel)			
Strength	Upper subbase soaked CBR ≥ 30%; every subbase at least the design CBR used for its cover (Figure 8.4)	AS 1289.6.1.1	**AGPT02 8.3.2**
Source	Crushed rock, or screened/crushed natural gravel; angular to sub-angular particles preferred	AS 1141.18	typical – confirm with Part 4A

Property	Requirement	Test	Source
Nominal size	20–40 mm (all passing 53 mm); not more than half the layer thickness	AS 1141.11	typical – confirm with Part 4A
Grading	Continuous, well graded; 0.075 mm passing 4–14%	AS 1141.11	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 10 (upper subbase), ≤ 12 (lower subbase)	AS 1289.3.3.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 40%; wet strength (10% fines) ≥ 50 kN	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 95% of modified MDD	AS 1289.5.2.1	typical – confirm with Part 4A
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Sources: *rows marked* ***AGPT02*** *are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B (asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.*

4.2 Alternative — Option 3 — Asphalt over granular (mechanistic-empirical, Section 8.2)

Reliability 95% (asphalt RF 6, SF 6) · subgrade CBR 20% · design traffic 4.68×10^7 ESA · granular 300 mm (normal standard) · subgrade ν 0.45

Asphalt layer	Thickness (mm)	Design E (MPa)	V_b (%)	Binder, mix	Source of E
Asphalt	235	3470	11	Class 320, 20 mm	Appendix K example

Fatigue: Equation 25 (conventional binders, Section 6.7.10).

Thicknesses tried: *60 mm ✗ (253.13), 65 mm ✗ (218.46), 70 mm ✗ (185.53), 75 mm ✗ (155.84), 80 mm ✗ (135.96), 85 mm ✗ (117.63), 90 mm ✗ (101.15), 95 mm ✗ (86.60), 100 mm ✗ (73.91), 105 mm ✗ (62.96), 110 mm ✗ (53.58), 115 mm ✗ (45.58), 120 mm ✗ (38.79), 125 mm ✗ (33.03), 130 mm ✗ (28.31), 135 mm ✗ (24.31), 140 mm ✗ (20.91), 145 mm ✗ (18.03), 150 mm ✗ (15.60), 155 mm ✗ (13.09), 160 mm ✗ (11.02), 165 mm ✗ (9.31), 170 mm ✗ (7.89), 175 mm ✗ (6.70), 180 mm ✗ (5.55), 185 mm ✗ (4.61), 190 mm ✗ (3.85), 195 mm ✗ (3.24), 200 mm ✗ (2.77), 205 mm ✗ (2.38), 210 mm ✗ (2.04), 215 mm ✗ (1.76), 220 mm ✗ (1.52), 225 mm ✗ (1.31), 230 mm ✗ (1.13), 235 mm ✓ (0.98). In brackets: the largest damage factor of the governing (applicable) checks.*

Option 3 — Asphalt over granular

✓ **Pavement OK** — all checks pass. Governing: asphalt fatigue (Asphalt) (0.985).

Total asphalt	Asphalt fatigue (design / allowable)	Subgrade rutting (design / allowable)	Result
235 mm	**0.985**	**0.000**	**OK**

Reliability / RF
95% / 6

Critical strains and damage

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Asphalt fatigue – bottom of Asphalt	235	108.2	93.0	by load (TLD)	TLD	0.985	✓ OK
Subgrade rutting – top of in situ subgrade	535	149.9	–	3.16×10^{12} ESA	4.68×10^{7} ESA	0.000	✓ OK

Fatigue damage by axle group type

Layer	SAST	TADT	TRDT	Total
Asphalt	0.0473	0.5324	0.4050	**0.985**

Pavement layers

Layer	Thickness (mm)	Design modulus E_v (MPa)	Model
Asphalt	235	3,470	isotropic, ν 0.4
Granular base + subbase (normal standard)	300	150 → 150	5 analysis sublayers, anisotropic (E_h = E_v/2), ν 0.35
Subgrade	semi-infinite	150	anisotropic (E_h = E_v/2), ν 0.45

Asphalt: structural thickness and construction lifts

Asphalt layer	Structural thickness (mm)	Mix	Construction lifts	Lift range (Table 6.11 / 12.1)
Asphalt	235	20 mm	3 × 78 mm (auto)	60–100 mm OK

▼ Equations and material sources used

Check	Equation / rule (AGPT02-26)	Inputs and source
Asphalt fatigue	Equation 25, N = (SF/RF) × [6918 (0.856 V_b + 1.08) / ($E^{0.36}$ με)]^5, SF 6, RF 6 (Table 6.17)	Asphalt: E 3470 MPa, Appendix K example, Class 320
Subgrade rutting	Equation 3, N = (9150 / με)^7; in situ and improved subgrade	E_v = 10 × CBR, max 150 MPa (Section 5.6); in situ ν 0.45
Granular modulus	Top sublayer = min(Table 6.4, Equation 42); 5 sublayers (Section 8.2.3)	Normal standard crushed rock
Traffic load	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.	

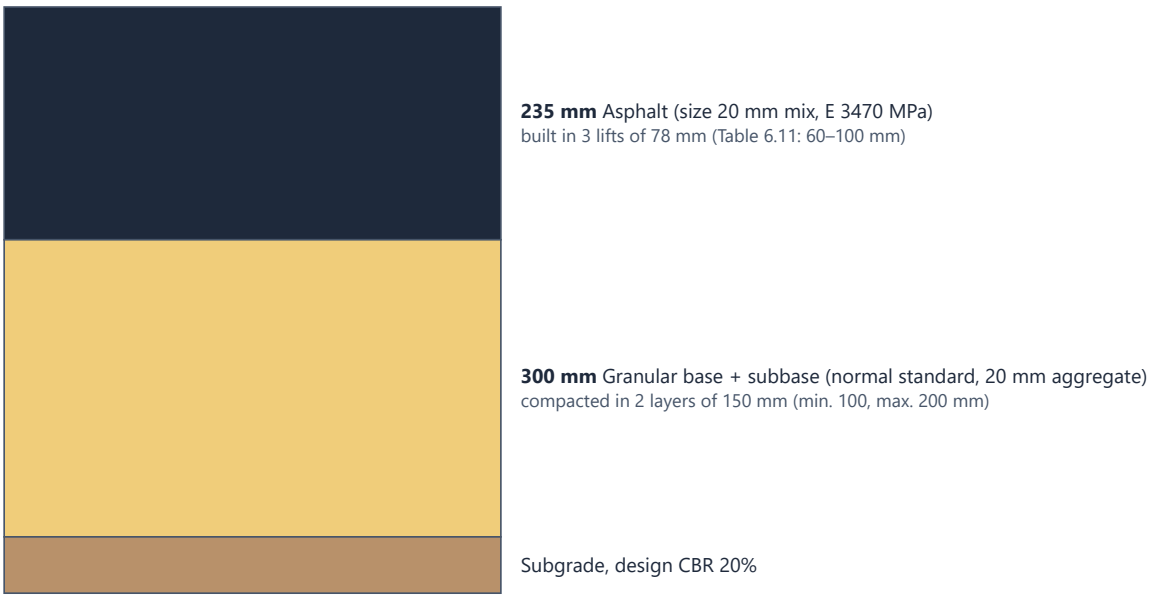
▼ Analysis model, every sublayer (for checking, e.g. in CIRCLY)

Layer	Thickness (mm)	E_v (MPa)	E_h (MPa)	ν
Asphalt	235	3,470	3,470	0.4
Granular – analysis sublayer 1 of 5	60	150	75	0.35
Granular – analysis sublayer 2 of 5	60	150	75	0.35
Granular – analysis sublayer 3 of 5	60	150	75	0.35
Granular – analysis sublayer 4 of 5	60	150	75	0.35
Granular – analysis sublayer 5 of 5	60	150	75	0.35
Subgrade	semi-infinite	150	75	0.45

*Granular and improved subgrade layers are split into 5 equal **analysis sublayers** only for the calculation (Sections 8.2.2–8.2.3): their stiffness changes with depth, so each sublayer gets its own modulus. They are not construction layers — build the base and subbase you specify in normal compaction lifts.*

```
Subgrade: Ev = min(10 × CBR 20, 150) = 150 MPa, Eh = Ev/2, ν = 0.45 (cohesive)
Granular top sublayer: min(Table 6.4 150 MPa [over 235 mm bound, Eeq 3470 MPa], Eq 42 792
MPa) = 150 MPa; 5 sublayers, ratio 1.000
Asphalt fatigue (Eq 25): N = SF/RF × [6918(0.856 Vb + 1.08)/(E^0.36 με)]^5, SF 6, RF 6; axle
groups use the strain of one axle (group load ÷ axles) and allowable ÷ axles
Subgrade rutting: N = (9150/με)^7 ESA
```

Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane. Asphalt layer 1: 235 mm structural thickness, built as 3 lifts of 78 mm (20 mm mix, Table 6.11 range 60–100 mm). Granular base + subbase 300 mm: built in 2 compaction layers of 150 mm (specification maximum 200 mm per layer, at least 100 mm for 20 mm maximum particle size). Austroads leaves the compaction layer limits to the construction specification (Section 3.7). Subgrade vertical modulus = 10 × CBR, limited to 150 MPa (Section 5.6).



Total asphalt 235 mm, granular 300 mm.

Option 3 — Asphalt over granular: cross-section (to scale).

Material specifications — Option 3

Property	Requirement	Test	Source
Dense-graded asphalt			
Mix size	Dense graded wearing course 7 or 10 mm (light traffic, low speed) or 10 or 14 mm (heavier traffic), 14 mm most common; base / intermediate layers e.g. 20 mm (Table 6.15 lists 10, 14 and 20 mm)	AS 2150	**AGPT02 2.2.4–2.2.5, Table 6.15**
Binder	Class 170 / 320 / 600, multigrade or A10E; the binder and mix size set the laboratory modulus (Table 6.15) used by the design-modulus helper	AS 2008	**AGPT02 Table 6.15**
Modulus test	Indirect tensile modulus at 25 °C, 40 ms rise time, 5% air voids; corrected for in-service air voids, WMAPT and speed; design modulus ≥ 1000 MPa	AS/NZS 2891.13.1	**AGPT02 6.7.5**
Binder volume V_b	Percentage by volume of bitumen, used in the fatigue equation (Equation 25); the guide's worked examples use 11%	—	**AGPT02 6.7.10, App. K**
Bond / waterproofing	Prime or initial seal under the asphalt on granular bases; tack coat between asphalt layers	—	**AGPT02 2.2.4–2.2.5**
Aggregate	Crushed rock, angular; flakiness index ≤ 25%; Los Angeles abrasion ≤ 30%; PAFV ≥ 44 in the wearing course	AS 1141.15 / .23 / .40	typical – confirm with Part 4B
In-place air voids	About 3–7% after compaction	AS/NZS 2891.9.2	typical – confirm with Part 4B
Layer thickness	Compacted layer 2.5–4 × nominal size	AS 2150	typical – confirm with Part 4B
Unbound granular base (crushed rock)			
Quality class	Normal-standard crushed rock (as commonly used by road agencies) or high-standard crushed rock: sound, durable igneous/metamorphic rock, highly processed to tight tolerances on durability, hardness, grading and Atterberg limits, placed to very high density and moisture standards	—	**AGPT02 6.2.3, Table 6.3**
Strength	Soaked CBR ≥ 80% (base quality)	AS 1289.6.1.1	**AGPT02 8.3.2**
Minimum thickness	Base thickness ≥ cover over CBR 30 material (Figure 8.4 / 12.2); at least 100 mm of crushed rock base where the asphalt surfacing is under 100 mm thick	—	**AGPT02 8.3.2, 12.6.1, 12.8.2**
Source	100% crushed quarried hard rock; angular particles with fractured faces	AS 1141.18	typical – confirm with Part 4A
Nominal size	20 mm (all passing 26.5 mm)	AS 1141.11	typical – confirm with Part 4A
Grading (% passing)	26.5 mm 100 · 19 mm 95–100 · 13.2 mm 77–93 · 9.5 mm 63–83 · 4.75 mm 44–64 · 2.36 mm 30–48 · 0.425 mm 13–21 · 0.075 mm 5–11	AS 1141.11	typical – confirm with Part 4A

Property	Requirement	Test	Source
Particle shape	Flakiness index ≤ 35%	AS 1141.15	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 6; linear shrinkage ≤ 3%	AS 1289.3.3.1 / 3.4.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 35%; wet strength (10% fines) ≥ 100 kN, wet/dry variation ≤ 35%	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 98% of modified MDD, at or just below OMC; dry back before sealing	AS 1289.5.2.1	typical – confirm with Part 4A
Unbound granular subbase (crushed rock or natural gravel)			
Strength	Upper subbase soaked CBR ≥ 30%; every subbase at least the design CBR used for its cover (Figure 8.4)	AS 1289.6.1.1	**AGPT02 8.3.2**
Source	Crushed rock, or screened/crushed natural gravel; angular to sub-angular particles preferred	AS 1141.18	typical – confirm with Part 4A
Nominal size	20–40 mm (all passing 53 mm); not more than half the layer thickness	AS 1141.11	typical – confirm with Part 4A
Grading	Continuous, well graded; 0.075 mm passing 4–14%	AS 1141.11	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 10 (upper subbase), ≤ 12 (lower subbase)	AS 1289.3.3.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 40%; wet strength (10% fines) ≥ 50 kN	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 95% of modified MDD	AS 1289.5.2.1	typical – confirm with Part 4A
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Sources: *rows marked* ***AGPT02*** *are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B*

(asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.

4.3 Alternative — Option 4 — Full-depth asphalt (mechanistic-empirical, Section 8.2)

Reliability 95% (asphalt RF 6, SF 6) · subgrade CBR 20% · design traffic 4.68 × 10^7 ESA · granular 0 mm (normal standard) · subgrade ν 0.45

Asphalt layer	Thickness (mm)	Design E (MPa)	V_b (%)	Binder, mix	Source of E
Asphalt	240	3470	11	Class 320, 20 mm	Appendix K example

Fatigue: Equation 25 (conventional binders, Section 6.7.10).

Thicknesses tried: *60 mm ✗ (1787.44), 65 mm ✗ (1338.55), 70 mm ✗ (1005.47), 75 mm ✗ (758.51), 80 mm ✗ (574.98), 85 mm ✗ (438.04), 90 mm ✗ (335.39), 95 mm ✗ (258.07), 100 mm ✗ (199.54), 105 mm ✗ (155.03), 110 mm ✗ (121.01), 115 mm ✗ (94.89), 120 mm ✗ (74.74), 125 mm ✗ (59.13), 130 mm ✗ (46.99), 135 mm ✗ (37.50), 140 mm ✗ (30.05), 145 mm ✗ (24.19), 150 mm ✗ (19.55), 155 mm ✗ (15.86), 160 mm ✗ (12.92), 165 mm ✗ (10.57), 170 mm ✗ (8.68), 175 mm ✗ (7.15), 180 mm ✗ (5.92), 185 mm ✗ (4.91), 190 mm ✗ (4.09), 195 mm ✗ (3.45), 200 mm ✗ (2.95), 205 mm ✗ (2.52), 210 mm ✗ (2.17), 215 mm ✗ (1.86), 220 mm ✗ (1.60), 225 mm ✗ (1.39), 230 mm ✗ (1.20), 235 mm ✗ (1.04), 240 mm ✓ (0.90). In brackets: the largest damage factor of the governing (applicable) checks.*

Option 4 — Full-depth asphalt

✓ **Pavement OK** — all checks pass. Governing: asphalt fatigue (Asphalt) (0.903).

Total asphalt	Asphalt fatigue (design / allowable)	Subgrade rutting (design / allowable)	Result
240 mm	**0.903**	**0.000**	**OK**

Reliability / RF
95% / 6

Critical strains and damage

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Asphalt fatigue – bottom of Asphalt	240	106.3	90.6	by load (TLD)	TLD	0.903	✓ OK
Subgrade rutting – top of in situ subgrade	240	240.4	–	1.16 × 10^{11} ESA	4.68 × 10^7 ESA	0.000	✓ OK

Fatigue damage by axle group type

Layer	SAST	TADT	TRDT	Total
Asphalt	0.0416	0.4893	0.3722	**0.903**

Pavement layers

Layer	Thickness (mm)	Design modulus E_v (MPa)	Model
Asphalt	240	3,470	isotropic, ν 0.4
Subgrade	semi-infinite	150	anisotropic (E_h = E_v/2), ν 0.45

Asphalt: structural thickness and construction lifts

Asphalt layer	Structural thickness (mm)	Mix	Construction lifts	Lift range (Table 6.11 / 12.1)
Asphalt	240	20 mm	3 × 80 mm (auto)	60–100 mm OK

▼ Equations and material sources used

Check	Equation / rule (AGPT02-26)	Inputs and source
Asphalt fatigue	Equation 25, $N = (SF/RF) \times [6918\ (0.856\ V_b + 1.08) / (E^{0.36}\ \mu\varepsilon)]^5$, SF 6, RF 6 (Table 6.17)	Asphalt: E 3470 MPa, Appendix K example, Class 320
Subgrade rutting	Equation 3, $N = (9150 / \mu\varepsilon)^7$; in situ and improved subgrade	E_v = 10 × CBR, max 150 MPa (Section 5.6); in situ ν 0.45
Traffic load	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.	

▼ Analysis model, every sublayer (for checking, e.g. in CIRCLY)

Layer	Thickness (mm)	E_v (MPa)	E_h (MPa)	ν
Asphalt	240	3,470	3,470	0.4
Subgrade	semi-infinite	150	75	0.45

*Granular and improved subgrade layers are split into 5 equal **analysis sublayers** only for the calculation (Sections 8.2.2–8.2.3): their stiffness changes with depth, so each sublayer gets its own modulus. They are not construction layers — build the base and subbase you specify in normal compaction lifts.*

```
Subgrade: Ev = min(10 × CBR 20, 150) = 150 MPa, Eh = Ev/2, ν = 0.45 (cohesive)
Asphalt fatigue (Eq 25): N = SF/RF × [6918(0.856 Vb + 1.08)/(E^0.36 με)]^5, SF 6, RF 6; axle groups use the strain of one axle (group load ÷ axles) and allowable ÷ axles
Subgrade rutting: N = (9150/με)^7 ESA
```

Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane. Asphalt layer 1: 240 mm structural thickness, built as 3 lifts of 80 mm (20 mm mix, Table 6.11 range 60–100 mm). Full-depth asphalt: keep the in situ subgrade above CBR 10% during construction and protect it from rain (Section 3.2.5). Subgrade vertical modulus = 10 × CBR, limited to 150 MPa (Section 5.6).



Total asphalt 240 mm, granular 0 mm.

Option 4 — Full-depth asphalt: cross-section (to scale).

Material specifications — Option 4

Property	Requirement	Test	Source
Dense-graded asphalt			
Mix size	Dense graded wearing course 7 or 10 mm (light traffic, low speed) or 10 or 14 mm (heavier traffic), 14 mm most common; base / intermediate layers e.g. 20 mm (Table 6.15 lists 10, 14 and 20 mm)	AS 2150	**AGPT02 2.2.4–2.2.5, Table 6.15**
Binder	Class 170 / 320 / 600, multigrade or A10E; the binder and mix size set the laboratory modulus (Table 6.15) used by the design-modulus helper	AS 2008	**AGPT02 Table 6.15**
Modulus test	Indirect tensile modulus at 25 °C, 40 ms rise time, 5% air voids; corrected for in-service air voids, WMAPT and speed; design modulus ≥ 1000 MPa	AS/NZS 2891.13.1	**AGPT02 6.7.5**
Binder volume V_b	Percentage by volume of bitumen, used in the fatigue equation (Equation 25); the guide's worked examples use 11%	—	**AGPT02 6.7.10, App. K**
Bond / waterproofing	Prime or initial seal under the asphalt on granular bases; tack coat between asphalt layers	—	**AGPT02 2.2.4–2.2.5**
Aggregate	Crushed rock, angular; flakiness index ≤ 25%; Los Angeles abrasion ≤ 30%; PAFV ≥ 44 in the wearing course	AS 1141.15 / .23 / .40	typical – confirm with Part 4B
In-place air voids	About 3–7% after compaction	AS/NZS 2891.9.2	typical – confirm with Part 4B
Layer thickness	Compacted layer 2.5–4 × nominal size	AS 2150	typical – confirm with Part 4B
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Sources: *rows marked **AGPT02** are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B (asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.*

4.4 Alternative — Option 5 — Asphalt + heavily bound cemented subbase (mechanistic-empirical, Section 8.2)

Reliability 95% (asphalt RF 6, SF 6; cemented RF not applicable, Eq 48) · subgrade CBR 20% · design traffic 4.68 × 10^7 ESA · granular 150 mm (normal standard) · subgrade ν 0.45

Asphalt layer	Thickness (mm)	Design E (MPa)	V_b (%)	Binder, mix	Source of E
Asphalt	190	3470	11	Class 320, 20 mm	Appendix K example

Fatigue: Equation 25 (conventional binders, Section 6.7.10).

Thicknesses tried: *60 mm ✗ (4330.56), 65 mm ✗ (3194.56), 70 mm ✗ (2371.84), 75 mm ✗ (1771.52), 80 mm ✗ (1330.44), 85 mm ✗ (1004.28), 90 mm ✗ (761.68), 95 mm ✗ (580.23), 100 mm ✗ (443.83), 105 mm ✗ (340.81), 110 mm ✗ (262.66), 115 mm ✗ (203.12), 120 mm ✗ (157.59), 125 mm ✗ (122.65), 130 mm ✗ (95.73), 135 mm ✗ (74.94), 140 mm ✗ (58.82), 145 mm ✗ (46.28), 150 mm ✗ (36.51), 155 mm ✗ (28.87), 160 mm ✗ (22.89), 165 mm ✗ (18.18), 170 mm ✗ (14.48), 175 mm ✗ (1.63), 180 mm ✗ (1.37), 185 mm ✗ (1.16), 190 mm ✓ (0.98). In brackets: the largest damage factor of the governing (applicable) checks.*

Option 5 — Asphalt + heavily bound cemented subbase

Table 6.4 look-up outside its range (bound cover 390 mm, equivalent modulus 3736 MPa; table 40–300 mm, 400–5000 MPa): the edge value of the table is used for the top granular sublayer.

✓ **Pavement OK** — all checks pass (the cemented layer cracks during the design life; the post-cracking phase carries the rest, Section 8.2.7). Governing: asphalt fatigue (Asphalt, both phases) (0.977).

Total asphalt	Asphalt fatigue (design / allowable)	Subgrade rutting (design / allowable)
190 mm	**0.977**	**0.000**

Cemented fatigue damage	Result	Reliability / RF
5.942	**OK**	**95% / 6 · n/a (Eq 48)**

Critical strains and damage — before the cemented layer cracks

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Asphalt fatigue – bottom of Asphalt	190	15.1	17.7	by load (TLD)	TLD	0.000	see phases
Cemented fatigue – bottom of Cemented subbase	390	51.8	38.1	by load (TLD)	TLD	5.942	cracks → post-cracking phase
Subgrade rutting – top of in situ subgrade	540	96.0	–	7.15×10^{13} ESA	4.68×10^{7} ESA	0.000	see phases

After the cemented layer cracks (cracked modulus 430 MPa)

Check	Depth (mm)	Strain, Standard Axle (με)	Strain, 53 kN single tyre (με)	Allowable	Design	Damage	Check
Asphalt fatigue – bottom of Asphalt — after cracking	190	111.3	105.1	by load (TLD)	TLD	1.169	see phases
Subgrade rutting – top of in situ subgrade — after cracking	540	178.7	–	9.21×10^{11} ESA	4.68×10^{7} ESA	0.000	see phases

Total allowable traffic, both phases (Equations 53–55)

Distress	Phase 1 allowable (ESA)	Phase 2 allowable (ESA)	Total allowable (ESA)	Design (ESA)	Check
Cemented fatigue (end of phase 1), $N_c = N_{HVAG} \times$ ESA/HVAG ÷ damage	7.88×10^6	–	–	–	ESA/HVAG 3.634
Asphalt fatigue – Asphalt	7.60×10^{11}	4.01×10^7	**4.80×10^7**	4.68×10^7	✓ OK
Subgrade rutting	7.15×10^{13}	9.21×10^{11}	**9.21×10^{11}**	4.68×10^7	✓ OK

Total = $N_c + (1 - N_c/N_1) \times N_2$ when $N_c < N_1$; otherwise the phase 1 allowable governs.

Fatigue damage by axle group type (before cracking)

Layer	SAST	TADT	TRDT	Total
Asphalt	0.0000	0.0000	0.0000	**0.000**
Cemented subbase	0.0034	2.8113	3.1274	**5.942**

Pavement layers

Layer	Thickness (mm)	Design modulus E_v (MPa)	Model
Asphalt	190	3,470	isotropic, ν 0.4
Cemented subbase	200	4,000	isotropic, ν 0.2
Granular base + subbase (normal standard)	150	150 → 150	5 analysis sublayers, anisotropic ($E_h = E_v/2$), ν 0.35
Subgrade	semi-infinite	150	anisotropic ($E_h = E_v/2$), ν 0.45

Asphalt: structural thickness and construction lifts

Asphalt layer	Structural thickness (mm)	Mix	Construction lifts	Lift range (Table 6.11 / 12.1)
Asphalt	190	20 mm	2 × 95 mm (auto)	60–100 mm OK

▼ Equations and material sources used

Check	Equation / rule (AGPT02-26)	Inputs and source
Asphalt fatigue	Equation 25, N = (SF/RF) × [6918 (0.856 V_b + 1.08) / ($E^{0.36}$ με)]^5, SF 6, RF 6 (Table 6.17)	Asphalt: E 3470 MPa, Appendix K example, Class 320
Subgrade rutting	Equation 3, N = (9150 / με)^7; in situ and improved subgrade	E_v = 10 × CBR, max 150 MPa (Section 5.6); in situ ν 0.45
Granular modulus	Top sublayer = min(Table 6.4, Equation 42); 5 sublayers (Section 8.2.3)	Normal standard crushed rock
Cemented fatigue	Equation 48 (presumptive, no reliability factor, Section 6.5.7)	Presumptive subbase crushed rock, 3–4% cement: E 4000 MPa, K 233
Post-cracking phase	Equations 53–55; cracked modulus Table 6.8 (Section 8.2.7)	Asphalt cover 190 mm (175 mm needed)
Traffic load	Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane.	

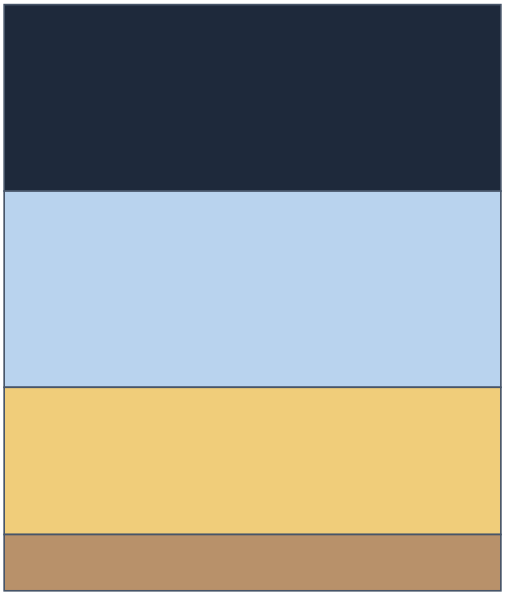
▼ Analysis model, every sublayer (for checking, e.g. in CIRCLY)

Layer	Thickness (mm)	E_v (MPa)	E_h (MPa)	ν
Asphalt	190	3,470	3,470	0.4
Cemented subbase	200	4,000	4,000	0.2
Granular – analysis sublayer 1 of 5	30	150	75	0.35
Granular – analysis sublayer 2 of 5	30	150	75	0.35
Granular – analysis sublayer 3 of 5	30	150	75	0.35
Granular – analysis sublayer 4 of 5	30	150	75	0.35
Granular – analysis sublayer 5 of 5	30	150	75	0.35
Subgrade	semi-infinite	150	75	0.45

*Granular and improved subgrade layers are split into 5 equal **analysis sublayers** only for the calculation (Sections 8.2.2–8.2.3): their stiffness changes with depth, so each sublayer gets its own modulus. They are not construction layers — build the base and subbase you specify in normal compaction lifts.*

```
Subgrade: Ev = min(10 × CBR 20, 150) = 150 MPa, Eh = Ev/2, ν = 0.45 (cohesive)
Granular top sublayer: min(Table 6.4 150 MPa [over 390 mm bound, Eeq 3736 MPa], Eq 42 345
MPa) = 150 MPa; 5 sublayers, ratio 1.000
Cemented subbase: Presumptive subbase crushed rock, 3–4% cement: E 4000 MPa, K 233; ν 0.2,
isotropic; fatigue N = (K/με)^12 (Equation 48, presumptive: reliability factor not
applicable)
Cracked cemented: Ev = min(600, Table 6.8 430, 4 × support 150 within 240–600) = 430 MPa, Eh
= Ev/2, ν 0.35 (Sections 6.5.2, 8.2.7)
Asphalt fatigue (Eq 25): N = SF/RF × [6918(0.856 Vb + 1.08)/(E^0.36 με)]^5, SF 6, RF 6; axle
groups use the strain of one axle (group load ÷ axles) and allowable ÷ axles
Subgrade rutting: N = (9150/με)^7 ESA
```

Traffic load distribution: your vehicle list (each axle group at its load and tyre width), 4.30E+06 heavy vehicles in the design lane. Asphalt layer 1: 190 mm structural thickness, built as 2 lifts of 95 mm (20 mm mix, Table 6.11 range 60–100 mm). Granular base + subbase 150 mm: built in one compaction layer (specification maximum 200 mm per layer, at least 100 mm for 20 mm maximum particle size). Austroads leaves the compaction layer limits to the construction specification (Section 3.7). Presumptive cemented material (Table 6.10): Equation 48 has no reliability factor — the selected project reliability is not available for cemented fatigue by this method (Section 6.5.7). Subgrade vertical modulus = 10 × CBR, limited to 150 MPa (Section 5.6).



Total asphalt 190 mm, granular 150 mm.

Option 5 — Asphalt + heavily bound cemented subbase: cross-section (to scale).

Material specifications — Option 5

Property	Requirement	Test	Source
Dense-graded asphalt			
Mix size	Dense graded wearing course 7 or 10 mm (light traffic, low speed) or 10 or 14 mm (heavier traffic), 14 mm most common; base / intermediate layers e.g. 20 mm (Table 6.15 lists 10, 14 and 20 mm)	AS 2150	**AGPT02 2.2.4–2.2.5, Table 6.15**
Binder	Class 170 / 320 / 600, multigrade or A10E; the binder and mix size set the laboratory modulus (Table 6.15) used by the design-modulus helper	AS 2008	**AGPT02 Table 6.15**
Modulus test	Indirect tensile modulus at 25 °C, 40 ms rise time, 5% air voids; corrected for in-service air voids, WMAPT and speed; design modulus ≥ 1000 MPa	AS/NZS 2891.13.1	**AGPT02 6.7.5**
Binder volume V_b	Percentage by volume of bitumen, used in the fatigue equation (Equation 25); the guide's worked examples use 11%	—	**AGPT02 6.7.10, App. K**
Bond / waterproofing	Prime or initial seal under the asphalt on granular bases; tack coat between asphalt layers	—	**AGPT02 2.2.4–2.2.5**
Aggregate	Crushed rock, angular; flakiness index ≤ 25%; Los Angeles abrasion ≤ 30%; PAFV ≥ 44 in the wearing course	AS 1141.15 / .23 / .40	typical – confirm with Part 4B
In-place air voids	About 3–7% after compaction	AS/NZS 2891.9.2	typical – confirm with Part 4B
Layer thickness	Compacted layer 2.5–4 × nominal size	AS 2150	typical – confirm with Part 4B
Heavily bound cemented subbase			
Parent material	Base-quality crushed rock, subbase crushed rock or natural gravel; soaked CBR ≥ 30% to model the cracked phase	AS 1289.6.1.1	**AGPT02 6.5.2**
Binder and modulus	Base 4–5% cement: E 5000 MPa; subbase crushed rock 3–4%: E 4000; subbase natural gravel 4–5%: E 3000 (typical values)	AS 3972	**AGPT02 Table 6.7**
Flexural strength / fatigue	Typical flexural strength 1.4 / 1.2 / 1.0 MPa, fatigue constant K 235 / 233 / 261; or K from laboratory modulus and flexural strength (Equation 14, cement-treated crushed rock or gravel, 3–5% binder, 1.0–1.5 MPa, 3000–5000 MPa)	AGPT/T600	**AGPT02 Table 6.10, Section 6.5.6**
Shrinkage control	Fines < 20% passing 75 µm and plasticity index ≤ 20; slow-setting binders preferred	AS 1141.11 / AS 1289.3.3.1	**AGPT02 6.5**
Cover	At least 175 mm asphalt (or 0.75 × granular + asphalt ≥ 175 mm) to count the post-cracking phase	—	**AGPT02 8.2.7**
Construction	Pugmill or in-situ mixing; compact ≥ 98% of modified MDD within the working time	AS 1289.5.2.1	typical – confirm with Part 4D
Curing	Moist cure 7 days; consider a stress-relieving seal to limit reflection cracking	—	typical – confirm with Part 4D
Unbound granular subbase (crushed rock or natural gravel)			

Property	Requirement	Test	Source
Strength	Upper subbase soaked CBR ≥ 30%; every subbase at least the design CBR used for its cover (Figure 8.4)	AS 1289.6.1.1	**AGPT02 8.3.2**
Source	Crushed rock, or screened/crushed natural gravel; angular to sub-angular particles preferred	AS 1141.18	typical – confirm with Part 4A
Nominal size	20–40 mm (all passing 53 mm); not more than half the layer thickness	AS 1141.11	typical – confirm with Part 4A
Grading	Continuous, well graded; 0.075 mm passing 4–14%	AS 1141.11	typical – confirm with Part 4A
Plasticity	Plasticity index ≤ 10 (upper subbase), ≤ 12 (lower subbase)	AS 1289.3.3.1	typical – confirm with Part 4A
Hardness	Los Angeles abrasion loss ≤ 40%; wet strength (10% fines) ≥ 50 kN	AS 1141.23 / 1141.22	typical – confirm with Part 4A
Compaction	≥ 95% of modified MDD	AS 1289.5.2.1	typical – confirm with Part 4A
Subgrade / selected or improved subgrade			
Strength	Design CBR as used in the design; improved layer at its own design CBR (Step 2: min 15%, lab CBR and Equation 56; Step 3: Section 8.2.2)	AS 1289.6.1.1	**AGPT02 5, 8.2.2, 8.3.2**
Lime-stabilised subgrade	Enough lime for long-term properties (lime demand test, Method B mix design); modulus as Section 8.2.2	Part 4D	**AGPT02 8.2.2**
Full-depth asphalt platform	In situ CBR > 10% at construction; very difficult below design CBR 5% (working platform or stabilisation)	—	**AGPT02 3.2.5**
Compaction	Top 150–300 mm ≥ 100% of standard MDD (≥ 95% below), within moisture limits	AS 1289.5.1.1	typical – confirm with Part 4A

Sources: *rows marked* ***AGPT02*** *are taken from the Guide to Pavement Technology Part 2 (2026) used by this tool. Rows marked typical – confirm with Part 4A / 4B / 4D / 4K are typical Austroads values still to be checked against Part 4A (granular base and subbase), 4B (asphalt), 4D (stabilised materials) or 4K (sprayed seals). The contract specification sets the binding limits.*

5. Comparison of pavement options

Abbreviations: ***ESA*** *= equivalent standard axle (a single axle with dual tyres carrying 80 kN);* ***DESA*** *= design traffic in ESA over the design period;* ***HVAG*** *= heavy vehicle axle group;* ***TLD*** *= traffic load distribution;* ***CBR*** *= California bearing ratio;* ***NHA*** *= National Highway Authority (Pakistan), whose legal axle load limits can fill the loads.*

Rank	Option	Pavement (mm)	Asphalt (mm)	Total (mm)	Governing check	Result	Austroads use: main road / rural highway
2	**Option 1 – Sprayed seal + granular (Step 2, empirical)**	Seal + 190 Crushed rock base + 100 Crushed rock upper subbase Empirical design (Figure 8.4) for your design traffic: 4.68 × 10^7 ESA	0	290	Figure 8.4 cover	✓ passes	**⚠ possible with conditions** Heavy traffic: only with high-standard materials, suitable environment and strict construction and maintenance (2.2.1, 2.2.2)
3	**Option 2 – Seal + lightly bound cemented base**	Seal + 290 lightly bound + 150 granular Mechanistic design (Section 8.2) for your design traffic: 4.68 × 10^7 ESA	0	440	lightly bound minimum thickness (Eq 44) (0.97)	✓ passes	✓ typical use Moderate-to-high traffic (8.2.4); upgrades local granular material
4	**Option 3 – Asphalt over granular**	235 asphalt + 300 granular Mechanistic design (Section 8.2) for your design traffic: 4.68 × 10^7 ESA	235	535	asphalt fatigue (0.98)	✓ passes	**⚠ possible with conditions** Rural highways and main roads depending on climate and traffic loads (2.2.5); heavy traffic: check asphalt and granular quality
★ 1	**Option 4 – Full-depth asphalt**	240 asphalt on the subgrade Mechanistic design (Section 8.2) for your design traffic: 4.68 × 10^7 ESA	240	240	asphalt fatigue (0.90)	✓ passes	✓ typical use Moderately to heavily trafficked roads, particularly urban (2.2.6)
5	**Option 5 – Asphalt + cemented subbase**	190 asphalt + 200 cemented (E 4000, K 233, presumptive, Eq 48) + 150 granular Mechanistic design (Section 8.2) for your design traffic: 4.68 × 10^7 ESA	190	540	asphalt fatigue (both phases) (0.98), cracks then post-cracking phase	✓ passes	✓ typical use Moderately to heavily trafficked roads, particularly urban (2.2.6)

Rank (★ = best) is by total thickness (fill every rate to rank by cost). Options that fail, are not recommended (e.g. Section 3.2.5) or are outside the validated range (QUALIFIED) are not ranked (–). The rank is a screening, not a recommendation on its own — see Choosing between the options below.

Costs per km (PKR) — quantities × your rates

Enter your rates in the **Rates** table above: the amounts, construction cost, maintenance and whole-of-life cost then fill in here straight away.

Item	Thickness (mm)	Quantity per km	Unit	Rate	Amount
Option 1 – Sprayed seal + granular (Step 2, empirical)					
Sprayed seal	–	7,300	m^2	enter rate	–
Granular base	190	1,387	m^3	enter rate	–
Granular subbase	100	730	m^3	enter rate	–
Construction cost					**–**
Maintenance, present value (reseal (needs seal rate))					–
Whole-of-life cost					**–**
Option 2 – Seal + lightly bound cemented base					
Sprayed seal	–	7,300	m^2	enter rate	–
Lightly bound cemented base	290	2,117	m^3	enter rate	–
Granular base + subbase	150	1,095	m^3	enter rate	–
Construction cost					**–**
Maintenance, present value (reseal (needs seal rate))					–
Whole-of-life cost					**–**
Option 3 – Asphalt over granular					
Asphalt	235	1,715	m^3	enter rate	–
Granular base + subbase	300	2,190	m^3	enter rate	–
Construction cost					**–**
Maintenance, present value (overlay (needs asphalt rate))					–
Whole-of-life cost					**–**
Option 4 – Full-depth asphalt					
Asphalt	240	1,752	m^3	enter rate	–
Construction cost					**–**
Maintenance, present value (overlay (needs asphalt rate))					–
Whole-of-life cost					**–**
Option 5 – Asphalt + cemented subbase					
Asphalt	190	1,387	m^3	enter rate	–
Cemented subbase	200	1,460	m^3	enter rate	–
Granular base + subbase	150	1,095	m^3	enter rate	–
Construction cost					**–**
Maintenance, present value (overlay (needs asphalt rate))					–
Whole-of-life cost					**–**

Observations

- For a **main road / rural highway** carrying 4.68×10^7 ESA, Austroads' typical uses point to **options 2, 4, 5**; options 1, 3 only with the conditions shown.

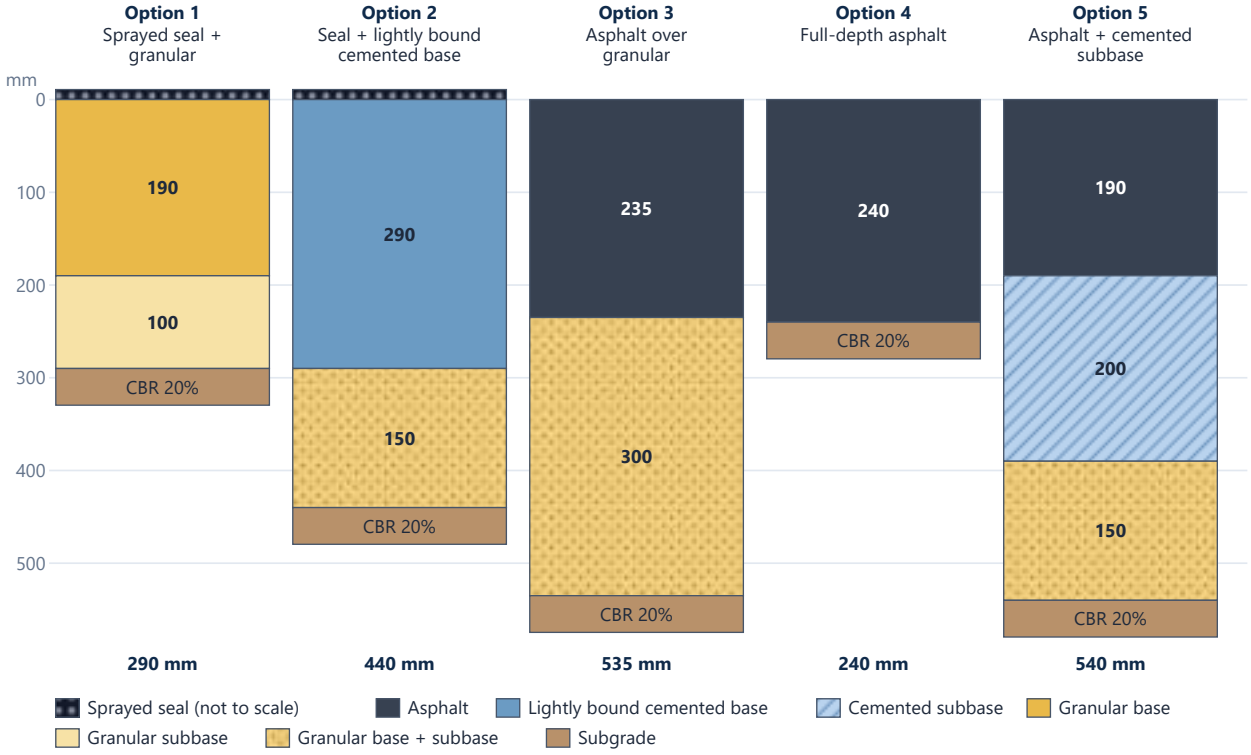
- Option 5 has 190 mm of asphalt against 235 mm in option 3 (total 540 vs 535 mm), with a 200 mm cemented subbase. Its cemented layer is calculated to crack during the design life (cemented damage 5.94), and the design counts the post-cracking phase (Equations 53–55): the asphalt and subgrade must carry the traffic in both phases. The comparison does not judge which is better beyond these checks and your costs; shrinkage cracking can reflect through the asphalt (Section 6.5). Enter rates to compare their cost.
- Full-depth asphalt (option 4) needs 5 mm more asphalt than option 3 and no granular base or subbase (the asphalt itself still uses quarried aggregate); the subgrade must be firm at construction (Section 3.2.5).
- Option 1 has no asphalt and is often the cheapest to build, but it has the least margin for overloading and wet conditions, and the seal has to be renewed periodically. Austroads uses sealed granular pavements mostly on light-to-moderate rural roads; heavy traffic needs excellent materials, drainage and maintenance (Section 2.2.2). Check agency practice — for example NHA requires an asphalt wearing course on national highways.
- The design traffic exceeds 10^7 ESA: a sealed granular pavement (options 1 and 2) at this traffic is outside common practice.
- Option 2 is governed by the lightly bound base rules (minimum thickness and support), not by fatigue; it suits sites where local granular material can be improved with a little binder.

Choosing between the options (Austroads AGPT02 Chapters 3 and 10)

Every passing option is a feasible design for the same traffic and subgrade. Austroads advises not to rely on the economic comparison as the sole determinant of the most appropriate option (Section 10.1). Weigh:

1. **Whole-of-life cost** (Section 10.1): the primary criterion — present worth of construction, maintenance and rehabilitation less salvage value over the analysis period (Equation 67, Sections 10.2–10.7). Use an analysis period not shorter than the longest design period, and test the discount rate at 4% and 10% as well as the base rate (Section 10.6).
2. **Materials available** (Sections 3.2, 3.6): the quality and haul distance of crushed rock, natural gravel and subbase materials, and the supply of cement, lime and bitumen. Stabilisation can make the best use of the materials available and reduce layer thicknesses (Section 3.6); where suitable drainage materials are lacking, use materials that do not weaken unduly when wet (Section 3.2).
3. **Climate and drainage** (Sections 3.2, 3.14.1): in high-rainfall areas or with high groundwater, provide subsurface drainage or a properly designed drainage layer; where that is not possible, keep water out or use bound materials. Soft, moisture-sensitive subgrades (in situ CBR below about 5% at construction) need treatment — drainage, replacement, a working platform or stabilisation (Section 3.14.1).
4. **Construction capability** (Sections 3.4, 3.11): the pavement type must suit the mixing, placing and compaction plant available — in remote areas the local equipment decides; on large projects importing plant may pay. When the road must be built under traffic, avoid types that need deep excavation or long curing.
5. **Traffic certainty and risk** (Sections 3.5, 3.13): where traffic or funds are uncertain, staged construction may be economical if the first stage suits the later ones (e.g. a base stiff enough for a later asphalt surfacing); take care staging bound layers, whose cracking can reflect into later layers. Prefer designs that are less sensitive to construction conditions: those that need ideal conditions carry a higher risk of early distress.
6. **Construction costs beyond the unit rates** (Section 10.3): local availability of suitable natural and processed materials, extra excavation or fill and shoulder material, traffic management, wet-weather delays (bound materials are quicker to build and avoid rework), establishment and supervision, and the scale of the project.
7. **Maintenance requirements and road user costs** (Sections 10.4, 10.8): include user delay costs where the alternatives need different amounts of maintenance on busy roads.
8. **Other criteria** (Section 10.1): potential differential settlement along the alignment, the need to build under traffic, noise and spray, safety and service to road users, and sustainability (greenhouse gas emissions).

9. **Typical use** of each pavement type for the road class and traffic (Section 2.2) — shown in the comparison table — and your road agency's own requirements (e.g. an asphalt wearing course on national highways).



Cross-sections of the passing options, all at the same vertical scale (thicknesses in mm; total thickness under each).
*Design traffic 4.68 × 10^7 ESA, subgrade CBR 20%, reliability 95%, asphalt E 3470 MPa and V_b 11% (bottom asphalt layer). Construction cost = quantity per km (thickness × width × 1000 m) × your rate, as itemised above. Each thickness is the **lowest passing tested candidate**: asphalt tried in 5 mm steps from the Table 6.11 minimum for the mix (and at least 40 mm), as one equivalent layer of the bottom-layer material; granular, cemented and improved layers fixed as stated. It is a candidate search, not an optimisation of every layer combination or of cost. Costs are for screening: routine maintenance, salvage value, shoulders and overheads are not included. Austroads compares options on whole-of-life cost, materials, construction and risk (Chapter 10).*

Design philosophy of the options

Where Austroads uses each option

Option	Where Austroads uses it (AGPT02-26 section)
Option 1 – Sprayed seal + granular	Major rural pavement type (about 90% of surfaced rural roads in Australia); most light and moderately trafficked rural roads; heavily trafficked roads only with suitable materials, environment, construction and maintenance (2.2.1, 2.2.2). With thin asphalt: residential and light urban streets, not urban freeways (2.2.4).
Option 2 – Sprayed seal + lightly bound cemented base	Guidance covers moderate-to-high design traffic only; no specific guidance for lightly trafficked roads (6.6, 8.2.4).
Option 3 – Asphalt over granular	Main use medium-traffic urban roads; may suit rural highways and main roads depending on climate and traffic (2.2.5).
Option 4 – Full-depth asphalt	Moderately to heavily trafficked roads, particularly urban; one of the heavy-duty pavement types for freeways (over 10^7 ESA) (2.2.1, 2.2.6).
Option 5 – Asphalt + heavily bound cemented subbase	Deep strength asphalt: moderately to heavily trafficked roads, particularly urban; one of the heavy-duty types for freeways (2.2.1, 2.2.6).

Austroads describes use by traffic level and rural/urban setting, not by road names. The road types in the tool (with Pakistani examples) are a guide; the design traffic decides. Agency rules also apply (e.g. NHA requires an asphalt wearing course on national highways).

Option 1 – Sprayed seal + granular (empirical, Sections 2.2.2 and 8.3). The unbound granular layers carry all the load; the sprayed seal (e.g. DST/TST) only waterproofs the pavement and gives skid resistance, so it has no structural value. The thickness comes from an empirical chart (Figure 8.4, or 12.2 for light traffic) that links design traffic and CBR to the cover each material needs so that rutting and loss of shape stay acceptable: every layer must have enough cover for its own CBR, and the base must be high-quality crushed rock (CBR ≥ 80%). It is the cheapest pavement to build and makes up about 90% of surfaced rural roads in Australia, but it relies on good materials, drainage and moisture control, and on resealing every few years; it is the most sensitive option to overloading and wet conditions.

Option 2 – Sprayed seal + lightly bound cemented base (Sections 6.6 and 8.2.4). A small amount of cementitious binder (28-day UCS 1–2 MPa) makes the base stiffer and less moisture-sensitive than granular material, but it is designed to be micro-cracked from the start, so no fatigue life is counted: it is modelled in its cracked state (modulus up to 600 MPa). The design keeps it micro-cracked only — never block or crocodile cracked — through a minimum thickness (Equation 44) and firm support (at least 150 mm of subbase with a top modulus of 150 MPa or more), and checks subgrade rutting. It can upgrade marginal granular materials; shrinkage cracking and construction quality need attention.

Option 3 – Asphalt over granular (Sections 2.2.5 and 8.2). The asphalt is both the wearing course and a structural layer; with less than about 150 mm of asphalt the granular base still provides much of the strength, so both asphalt fatigue and deformation matter. The mechanistic-empirical method works out the tensile strain at the bottom of the asphalt and the compressive strain on top of the subgrade under the Standard Axle and converts them, through the guide's performance relationships, into allowable traffic for asphalt fatigue and subgrade rutting; the asphalt thickness is chosen so the damage is at most 1 at the chosen reliability. A hot climate (high WMAPT) softens the asphalt and shortens its fatigue life, so it needs more thickness; the granular materials must be of high quality and well drained.

Option 4 – Full-depth asphalt (Sections 2.2.6 and 3.2.5). All the structural capacity is in asphalt laid directly on the subgrade (or on an improved subgrade / working platform). Asphalt fatigue usually governs and subgrade rutting is checked as well. The pavement is thin, quick to build and needs no granular materials, but the subgrade must be firm when the asphalt is laid: the guide notes it is very difficult to build on a design CBR below 5% and needs an in situ CBR above 10% at construction, so weak or moisture-sensitive subgrades need improvement or a working platform. Asphalt is the most expensive material per cubic metre.

Option 5 – Asphalt + heavily bound cemented subbase (Sections 6.5, 8.2 and 8.2.7). A stiff cement-treated subbase spreads the load and lowers the strains in the asphalt and subgrade. The design checks asphalt fatigue, subgrade rutting and the fatigue of the cemented layer itself, which is very sensitive to strain (12th-power law). With at least 175 mm of asphalt cover the pavement may continue after the cemented layer cracks: it then behaves like a stiff granular layer (modulus up to 600 MPa) and the remaining asphalt and subgrade lives are added (Equations 53–55). With less cover the cemented layer must last the whole design traffic. Shrinkage cracking can reflect through the asphalt, so cover thickness, binder choice and curing matter.

All five use the same design traffic and subgrade. Thicknesses are minimum design values; Austroads chooses between acceptable options on whole-of-life cost, materials, construction and risk (Table 8.3 Step 32, Chapter 10).

Scope and limitations

What this tool designs. New flexible pavements to Austroads AGPT02-26 (Edition 5.2): the empirical granular design with sprayed seal or thin asphalt under 40 mm (Figure 8.4 / 12.2), and mechanistic-empirical designs of asphalt over granular, full-depth asphalt, asphalt over one heavily bound cemented subbase, and sprayed seal over a lightly bound base (Section 8.2).

Item	Supported range in this tool
Design traffic	10^3–10^8 ESA (Step 2: below 10^3 the 10^3 line is used); lightly bound base only from 10^5 ESA
Traffic load distribution	A project load spectrum from the vehicle mix (Step 1). The Austroads example distribution gives a QUALIFIED (demonstration) result
Subgrade	Design CBR 2–30% on the chart (below 2% extrapolated: QUALIFIED; above 30% the 30 line is used); E_v = 10 × CBR up to 150 MPa; ν 0.45 cohesive or 0.35 non-cohesive
Granular materials	Base design CBR ≥ 80%; normal or high standard crushed rock (Tables 6.4/6.5)
Asphalt	Dense graded, conventional binders (Class 170/320/600); total ≥ 40 mm in Step 3; V_b up to 25%; layer and lift thickness to Table 6.11
Cemented subbase	One layer, presumptive Table 6.7/6.10 values or laboratory values within Equation 14 limits (3–5% binder, 3000–5000 MPa, 1.0–1.5 MPa); post-cracking phase only with ≥ 175 mm of asphalt over it
Improved subgrade	One layer (Equation 56 in Step 2, Section 8.2.2 in Step 3)

Not covered — outside the tool or left to the designer:

- Subgrade evidence: the tool uses the design CBR you enter. Representative moisture, density, variability, drainage, expansive soils and weak layers below still have to be assessed (Chapter 5). The in-service design CBR is not the in situ CBR needed during asphalt construction (Section 3.2.5).
- Material limits: each real material must be able to reach the modulus assigned to it (Section 8.2.3); subbase material limits are not checked from a material schedule. Structural adequacy is not evidence of compaction, drainage, bond, curing or a working platform.
- Structures not modelled: more than one improved layer, granular cover above a cemented layer (so the 0.75 × granular cover alternative of Section 8.2.7 is not implemented), lean-mix concrete and rigid pavements, overlays and rehabilitation.
- Distress not captured by the two strain criteria: horizontal braking and turning loads, partial bond, thermal, top-down and reflection cracking, and rutting within the asphalt.
- Traffic: growth in numbers is modelled; changes in axle-load magnitude over time (Appendix E) are not. The optional temperature-dependent asphalt traffic caps (Section 7.6.3, Table 7.9) are not applied (generally conservative; they never apply to cemented fatigue or subgrade rutting).
- Costs: layer quantities and periodic reseals or overlays only; routine maintenance, user costs, salvage value (Equation 67), shoulders and overheads are excluded. Use them for screening, not as a project whole-of-life ranking.
- External inputs not from Austroads: the Pakistan NHA axle-load limits, the NHA-practice minimum subgrade CBR and the Lahore temperature normals (PMD, via Wikipedia) must be checked against the original agency source before use.
- Approval: results are calculation output; a qualified pavement engineer must check the design basis, constructability, road-agency supplement, drainage, specifications and cost scope.

Method and references

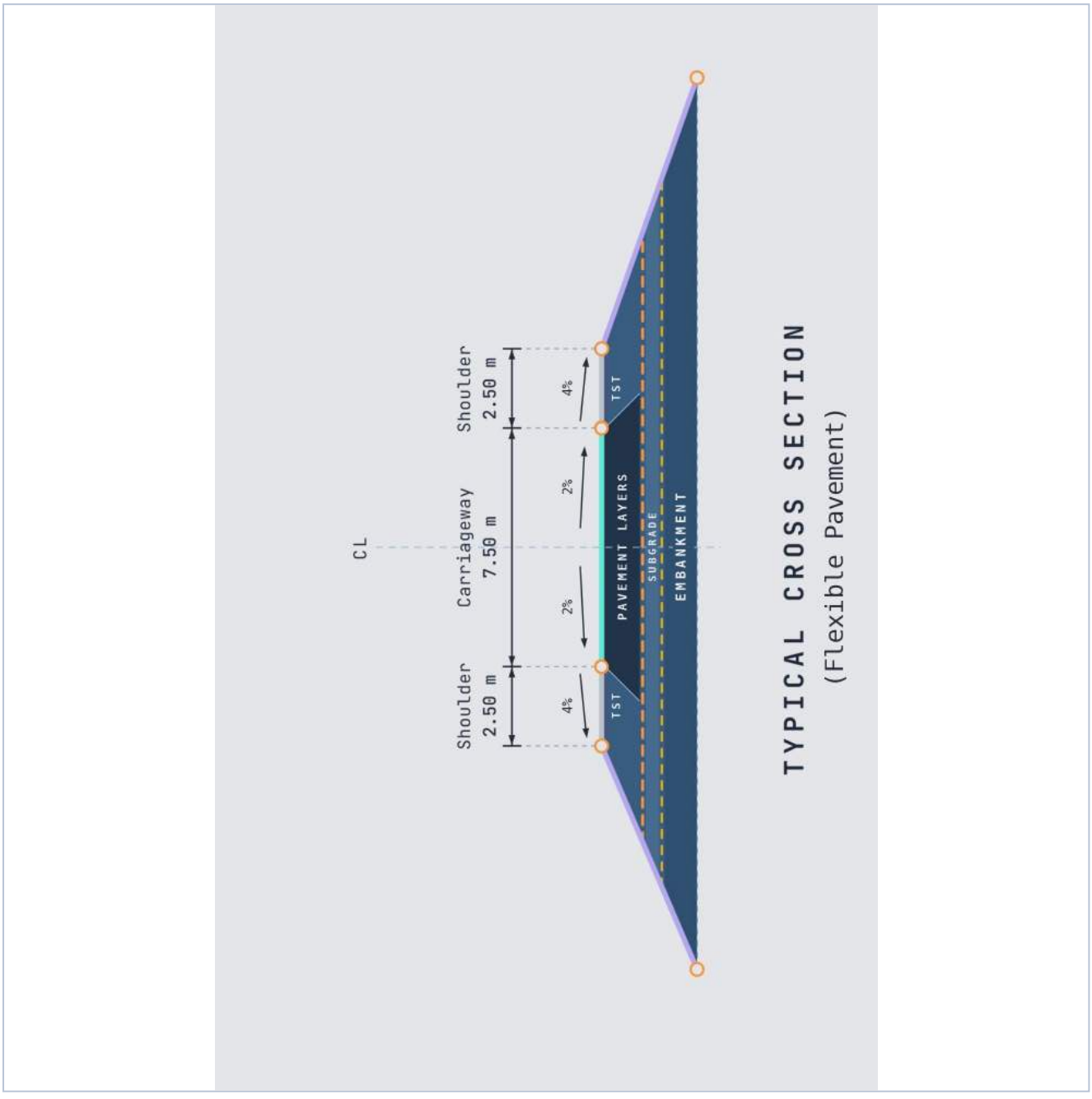
- **ESA of an axle group** = $(L / SL)^4$ (Equation 37). Standard Loads SL: SADT 80, TADT 135, TRDT 182, QADT 226 kN (Table 7.7); single-tyre groups by tyre width (Table 7.8): SAST 53/58/71, TAST 89/98/119, TRST 121/132/162, QAST 150/164/201 kN.
- **Initial daily heavy vehicles in the design lane** n = AADT × DF × %HV/100 × LDF (Equation 30). In the vehicle mix, n = Σ vehicles per day × DF × LDF.

- **Cumulative growth factor** CGF = $((1 + 0.01R)^P - 1) / (0.01R)$, CGF = P when R = 0 (Equation 31). Cumulative HV N_{DT} = 365 × CGF × n (Equation 32), or the year-by-year sum capped at capacity (Equations 33–34, Section 7.4.6).
- **Axle groups** $N_{DT,HVAG} = N_{DT} \times N_{HVAG}$ (Equation 35); **design traffic** DESA = ESA/HVAG × $N_{DT,HVAG}$ (Equation 38).
- **Cover over a material**, DESA 10^5–10^8 (Figure 8.4): $t = [219 - 211(\log CBR) + 58(\log CBR)^2] \log(DESA/120)$. DESA 10^3–10^5 (Figure 12.2): $t = \max\{100, 0.475[219 - 211(\log CBR) + 58(\log CBR)^2] \log(14\ DESA)\}$. Materials with CBR ≥ 30 use the CBR 30 line; that cover is the minimum base thickness (CBR ≥ 80 base).
- **Mechanistic-empirical design (Step 3, Section 8.2)**: linear elastic layered analysis under the Standard Axle (4 × 20 kN, 750 kPa, radius 92.1 mm, spacing 330/1470/330 mm) and the 53 kN single-tyre axle (2 × 26.5 kN, 800 kPa, radius 102.4 mm, 2130 mm); asphalt isotropic (ν 0.4); granular and subgrade anisotropic ($E_h = E_v/2$, ν 0.35 / 0.45, $f = E_v/(1+\nu)$; in situ subgrade ν 0.45 cohesive or 0.35 non-cohesive, as selected); granular in 5 sublayers (Equations 42–43, Tables 6.4/6.5); asphalt fatigue $N = SF/RF \times [6918(0.856V_b + 1.08)/(E^{0.36}\mu\varepsilon)]^5$ (Equation 25, SF 6, RF Table 6.17) summed over the traffic load distribution; subgrade $N = (9150/\mu\varepsilon)^7$. Heavily bound cemented subbase: isotropic (ν 0.2) before cracking with fatigue $N = RF \times (K/\mu\varepsilon)^{12}$ for laboratory values (Equation 47, K from Equation 14 capped by Equation 13, RF Table 6.9) or $N = (K/\mu\varepsilon)^{12}$ for presumptive values (Table 6.10, Equation 48, no reliability factor); after cracking cross-anisotropic, E_v = min(600, Table 6.8, 4 × support within 240–600), ν 0.35, with total allowable traffic from Equations 53–55 (needs 175 mm asphalt cover). Engine checked against the CIRCLY results of Appendix K.1–K.3 (strains within 0.5%, asphalt damage within 1–2%; cemented damage reproduced exactly from the guide's strains, the 12th power turns a 0.7% strain difference into about 9%). Lightly bound cemented base (Sections 6.6, 8.2.4): cracked behaviour only, E_v = min(600, Table 6.8 under asphalt, 4 × support within 240–600), $E_h = E_v/2$, ν 0.35; minimum thickness $\max[200, 250 + 35 \log(DESA/5\times10^6) - 0.25(E_{under} - 150)]$ (Equation 44, less any asphalt, not below 200 mm) and minimum support (subbase ≥ 150 mm, top sublayer ≥ 150 MPa); checked against Appendix K.4 (subgrade strain 827 με, minimum thickness 255 mm). Selected / improved subgrade (Section 8.2.2): 5 sublayers, top E_v = min(150, 10 × CBR, $E_{under} \times 2^{t/150}$) (Equation 40), ratio from Equation 41, $E_h = E_v/2$, ν 0.45; rutting checked on top of it and on the in situ subgrade; over 2 m it is taken as the subgrade. Full-depth asphalt warnings follow Section 3.2.5 (design CBR below 5%: very difficult to build; in situ CBR above 10% needed at construction). Lean-mix concrete is not included.
- **Pakistan NHA legal axle load limits** (National Highways Safety Ordinance 2000 axle load regime, as published by NHA): front single axle 5.5 t, single axle with dual tyres 12 t, tandem 22 t, tridem 31 t (1 t = 9.80665 kN). Gross weights follow from these, e.g. 22-wheeler 5.5 + 22 + 31 = 58.5 t. Check the current NHA notification before use.
- **Improved subgrade design CBR** = $\min\{15, \text{lab CBR}, CBR_{below} \times 2^{(thickness/150)}\}$ (Equation 56).
- A thin DGA/SMA surfacing counts towards the total cover over the in situ subgrade but not towards the base; sprayed seals count for nothing (Section 8.3.2).
- The guide's worked examples read values off the chart; this tool uses the chart equations and the rounding you pick, so results can differ from hand-read values by a few mm.
- Thicknesses are minimum design values and take no account of construction tolerance (Section 8.1). CBR is not the only test of a granular material (Section 6.2.1). Asphalt fatigue of thin surfacings is not covered by this chart (Section 8.3).
- Source: Austroads (2026) *Guide to Pavement Technology Part 2: Pavement Structural Design*, AGPT02-26, Sydney. This free tool is independent and not endorsed by Austroads; check designs against the guide and your road agency's supplement.

Generated with the free Austroads Pavement Design tool at shahidpervaiz.net. Results must be checked by a qualified pavement engineer.

ANNEXURE – C (TYPICAL CROSS SECTIONS)

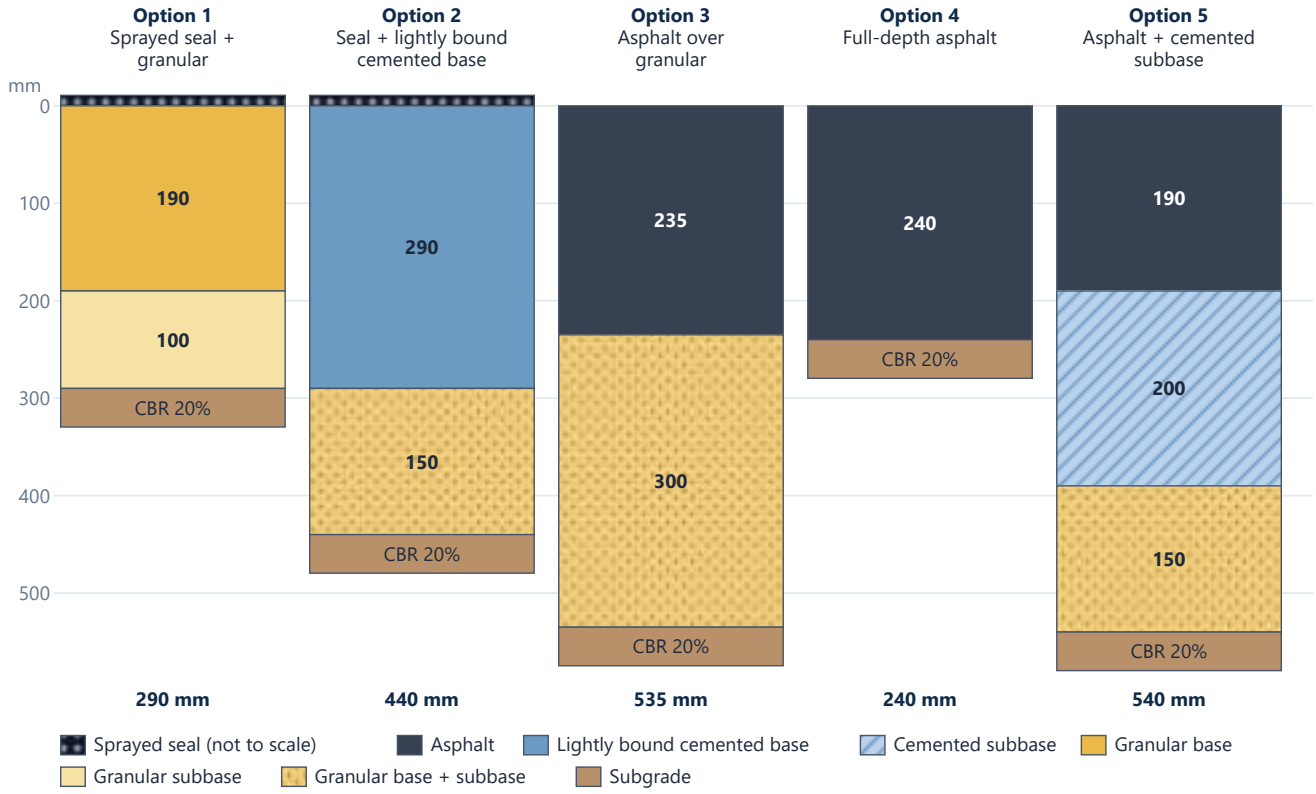
Referred to in: Executive Summary, 4.4 Recommended Pavement.



Sample drawing — insert the actual project cross section to replace this sample (upload it in the report form under Annexure C; use + Add cross section for more sections).

Pavement layers (to scale)

Pavement options drawn to scale by the tool (layer thicknesses in mm).



Selected pavement



50 mm Asphalt wearing course (14 mm mix) (E 3150 MPa)
built in one lift (Table 6.11: 45–70 mm)

100 mm Asphalt base course (20 mm mix) (E 3470 MPa)
built in one lift (Table 6.11: 60–100 mm)

300 mm Granular base + subbase (normal standard, 20 mm aggregate)
compacted in 2 layers of 150 mm (min. 100, max. 200 mm)

Subgrade, design CBR 20%

Total asphalt 150 mm, granular 300 mm.

ANNEXURE – D (SOIL INVESTIGATION RESULTS OF CBR)

Referred to in: Executive Summary, 3.2 Subgrade Design CBR.

A subgrade design CBR of **20%** has been adopted in this design (see part 3.2 of this report).

Full soil and material investigation report, borehole logs and laboratory CBR test results to be attached separately by the design engineer (upload images or PDFs in the report form; + Add report / page for more).

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