UNIVERSITY OF JOHANNESBURG

PROGRAM	:	B TECH *CIVIL ENGINEERING TECHNOLOGY*
SUBJECT	:	**PAVEMENT TECHNOLOGY 4**
CODE	:	**PVT411**
DATE	:	WINTER EXAMINATION 2015 15 JUNE 2015
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	**60:40**
TOTAL MARKS	:	100

EXAMINER	:	DR HA QUAINOO
MODERATOR	:	MR I. ARIYO
NUMBER OF PAGES	:	PAGES 12

INSTRUCTIONS	:	PLEASE ANSWER ALL THE QUESTIONS.
REQUIREMENTS	:	GRAPH PAPER

UNIVERSITY OF JOHANNESBURG
DEPARTMENT OF CIVIL ENGINEERING
PVT411: PAVEMENT TECHNOLOGY 4

MAY/JUNE EXAM 2015
ANSWER ALL QUESTIONS – TIME ALLOWANCE: 3 HOURS

Question 1

(a) A new bitumen-surfaced road is planned for construction in two months' time. Data about the proposed road are as follows:

- Structural Design Period 25 years
- Analysis Period 40 years
- Design reliability 95%
- Constructed Riding Quality (PSI) 4.5
- Terminal Riding Quality (PSI) 2.5

With the aid of an appropriate diagram, briefly explain the type of maintenance strategy that would enable the proposed road to last up to forty (40) years. **[7 marks]**

(b) Briefly discuss how the Dynamic Cone Penetrometer (DCP) could be used to estimate the remaining life of pavements. **[5 marks]**

(c) An existing road with a double seal surface is to be assessed for traffic capacity. A series of dynamic cone penetrometer readings were taken.

The table below gives readings from a dynamic cone penetrometer, first read every 5 blows and later every blow. Graph paper is provided. Find the thickness and DCP Number (mm/blow) for each layer and calculate the equivalent CBR value.
In addition, allocate a material code to each layer. Using the design catalogue for wet regions provided, assess the traffic carrying capacity of the road structure.

No. of blows	DCP reading mm	No of blows	DCP reading mm
0	75	87	640
5	90	88	660
10	105	89	680
15	120	90	700
20	135	91	725
25	150	92	745
30	165	93	768
35	180	94	790
40	195	95	810
45	210	96	835
50	225	97	860
55	265	98	882
60	305		
65	345		
70	385		
75	445		
80	510		
85	600		
86	620		

[13 marks]

Question 2

A new six lane freeway is to be constructed in a high rainfall region based on an estimated present average daily traffic (ADT) of 4 000 vehicles per day in both directions. The traffic growth rates are expected to be 4.5% until the road is opened to traffic in five years' time and thereafter 7% up to the end of its design life. Heavy vehicles, averaging 0.92 E80s each, comprise 20% of the total traffic.

(i) Calculate the predicted design traffic at the end of the structural design period of 25 years and state the design traffic class.

(ii) If the design California Bearing Ratio of the subgrade averages 5%, propose a pavement design using the catalogue method over the full material depth for a structural design period stated above using a granular base.

[25 marks]

Question 3

A newly constructed section of a road is to be surfaced with 13.2 + 6.7 mm double seal. Details of the road, conditions and specifications are as follows:

- Traffic: Heavy vehicles = 400 per day per lane
  Light vehicles = 2400 per day per lane
- Terrain: Rolling with gradient greater than 4%. Design speed of slow-moving vehicles is 35 km/h for which an adjustment of 5% is required for the net cold binder.
- Climate: Dry region, and requires an adjustment of 10% of net cold binder
- Texture Depth: The existing texture depth is uniform on this section with an average of 0.5 mm
- Embedment Potential: The average corrected Ball Penetration value on this section is 1.0 mm
- Aggregate: The aggregates delivered on site conforms to SANS specifications
  - ALD of 13.2 mm aggregate = 8.1 mm with flakiness index of 0%
  - ALD of 6.7 mm aggregate = 3.7 mm with flakiness index of 10%
- Policies:
  - Aggregate spread rate: a dense shoulder-to-shoulder matrix is preferred for the first aggregate layer
  - Pre-coating of the second layer is recommended
  - Hot spray: 80/100 Penetration Grade bitumen is to be used.

Using the TRH3 design catalogue, provide a full double seal design surfacing for the road. (For pre-coated of aggregates, binder proportions are as follows: Tack coat = 55%; Penetration = 45%; Fog spray = 0%).

[25 marks]

Question 4

(a) You have been appointed a special advisor to the MEC of Transportation, Province X. Briefly discuss how the Province should efficiently manage its road maintenance programme. **[8 marks]**

(b) As a special advisor to Municipality Y Road Infrastructure Development Board, you have been approached by the MEC for Infrastructure Road Development to assist in the selection of a proposed road design project. Two alternative designs presented to the municipality are shown in Table 4. In addition: for Design A, the annual operating cost is R1 200 000 throughout its life; for Design B, the annual operating cost is R1 000 000 for the first 25 years and R1 300 000 for the remaining 5 years. The interest rate is 12 percent.

Determine which machine is more economical by using **Net Present Value** method. Substantiate your conclusion with logic and calculation.

Table 4: Data for alternative turbines

	Design Alternative A	Design Alternative B
Cost (R)	9 000 000	10 000 000
Annual Toll (revenue) (R)	700 000	900 000
Design life (years)	20	30

Please state every assumption made.

Using **Net Present Value** analysis, determine which of the two design alternatives is a better option. (Hint: $F = P\,(1+i)^n$; $P = A\,[\,(1+i)^n - 1\,] / [\,i * (1+i)^n\,]$) **[17 marks]**

EQUATIONS, FUNCTIONS, MISCELLANEOUS INFORMATION, & DESIGN CHARTS

- Equivalent CBR from DCP values:

$$CBR = \frac{401.8}{(\text{DCP Number})^{1.284}}$$

- CBR values for various layers are given in the table below:

Material Code	Minimum CBR	Layer
G4	80	Gravel base
G5	45	Subbase
G6	25	Subbase / selected
G7	15	Selected
G8	10	Subgrade
G9	7	Subgrade
G10	3	Subgrade

GRANULAR BASES (WET REGIONS) DATE 1996

PAVEMENT CLASS AND DESIGN BEARING CAPACITY (80 kN AXLES/LANE)

ROAD CAT.	ES0.003 < 3000	ES0.01 0,3-1,0x10^4	ES0.03 1,0-3,0x10^4	ES0.1 3,0-10x10^4	ES0.3 0,1-0,3x10^6	ES1 0,3-1,0x10^6	ES3 1,0-3,0x10^6	ES10 3,0-10x10^6	ES30 10-30x10^6	ES100 30-100x10^6	Foundation
A							30A 150 G1** 200 C3	40A 150 G1 300 C3 *(250 C3)	50A 150 G1 400 C3 *(300 C3)		150 G7 150 G9 G10
B						S 150 G2 150 C4 S 150 G2 200 G5	S/30A 150 G1** 200 C4	40A 150 G1 300 C4 *(250 C4)			
C				S 100 G5 125 C4 S 125 G4 125 G5	S 125 G5 125 C4 S 150 G4 150 G6	S 125 G2 150 C4 S 150 G2 150 G5	S 150 G2** 200 C4 S 150 G2 150 G4				
D	S1 100 G5 100 G7	S1 100 G5 125 G7	S1 100 G4 125 G7	S1 100 G4 125 G6 S1 100 G5 100 C4	S 125 G4 125 G6 S 100 G5 125 C4	S 150 G4 150 G6 S 125 G5 150 C4					150 G9 G10

Symbol A denotes AG, AC, OR AS. A0, AP may be recommended as a surfacing measure for improved skid resistance when wet or to reduce water spray.

S denotes Double Surface Treatment (seal or combinations of seal and slurry)

S1 denotes Single Surface Treatment

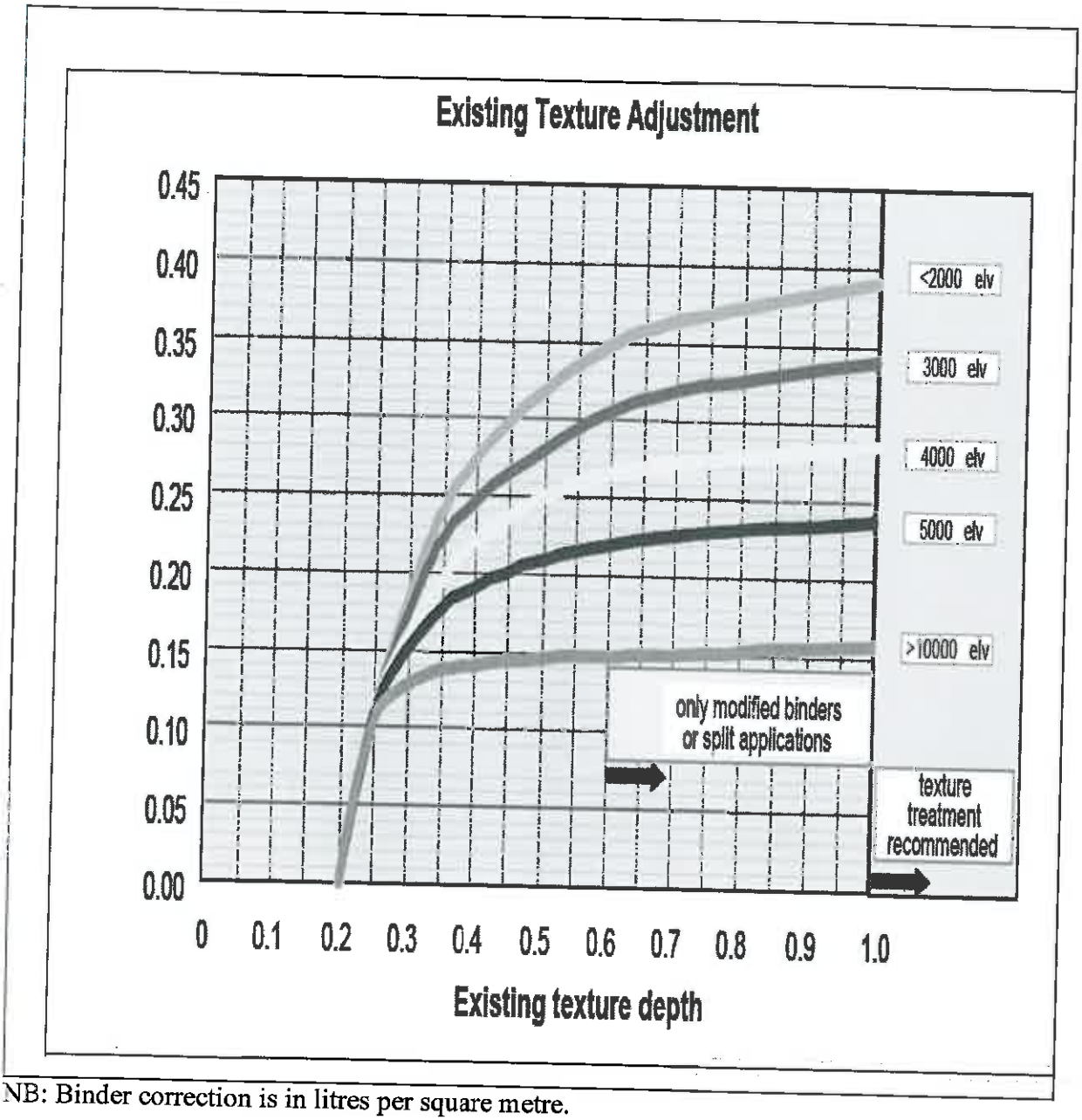
* If water is prevented from entering the base, the subbase thickness may be reduced to the values indicated in brackets.

** Base thickness may be reduced by 25 mm if cemented subbase thickness is increased by 50 mm.

TABLE 12

Traffic growth factor (f_y) for calculation of cumulative traffic over prediction period from initial (daily) traffic

Prediction period, y (years)	f_y for traffic increase, i (% per annum)									
	2	4	6	8	10	12	14	16	18	20
4	1 534	1 611	1 692	1 776	1 863	1 953	2 047	2 145	2 246	2 351
5	1 937	2 056	2 180	2 312	2 451	2 597	2 750	2 911	3 081	3 259
6	2 348	2 517	2 698	2 891	3 097	3 317	3 551	3 801	4 068	4 349
7	2 767	2 998	3 247	3 517	3 809	4 124	4 464	4 832	5 229	5 657
8	3 195	3 497	3 829	4 192	4 591	5 028	5 506	6 029	6 601	7 226
9	3 631	4 017	4 445	4 922	5 452	6 040	6 693	7 417	8 220	9 109
10	4 076	4 557	5 099	5 710	6 398	7 173	8 046	9 027	10 130	11 369
11	4 530	5 119	5 792	6 561	7 440	8 443	9 588	10 895	12 384	14 081
12	4 993	5 703	6 526	7 480	8 585	9 865	11 347	13 061	15 044	17 336
13	5 465	6 311	7 306	8 473	9 845	11 458	13 352	15 575	18 183	21 241
14	5 947	6 943	8 130	9 545	11 231	13 242	15 637	18 490	21 887	25 927
15	6 438	7 600	9 005	10 703	12 756	15 239	18 242	21 872	26 257	31 551
16	6 939	8 284	9 932	11 953	14 433	17 477	21 212	25 795	31 414	38 299
17	7 450	8 995	10 915	13 304	16 278	19 983	24 598	30 346	37 500	46 397
18	7 971	9 734	11 957	14 762	18 308	22 790	28 458	35 625	44 680	56 115
19	8 503	10 503	13 061	16 338	20 540	25 934	32 859	41 748	53 154	67 776
20	9 045	11 303	14 232	18 039	22 995	29 455	37 875	48 851	63 152	81 769
25	11 924	15 808	21 227	28 818	39 486	54 506	75 676	105 517	147 559	206 727
30	15 103	21 289	30 587	44 656	66 044	98 656	148 459	224 533	340 661	517 664
35	18 612	27 958	43 114	67 927	108 816	176 464	288 595	474 509	782 431	1 291 373
40	22 487	36 071	59 877	102 120	177 700	313 586	558 416	999 544	1 793 095	3 216 609

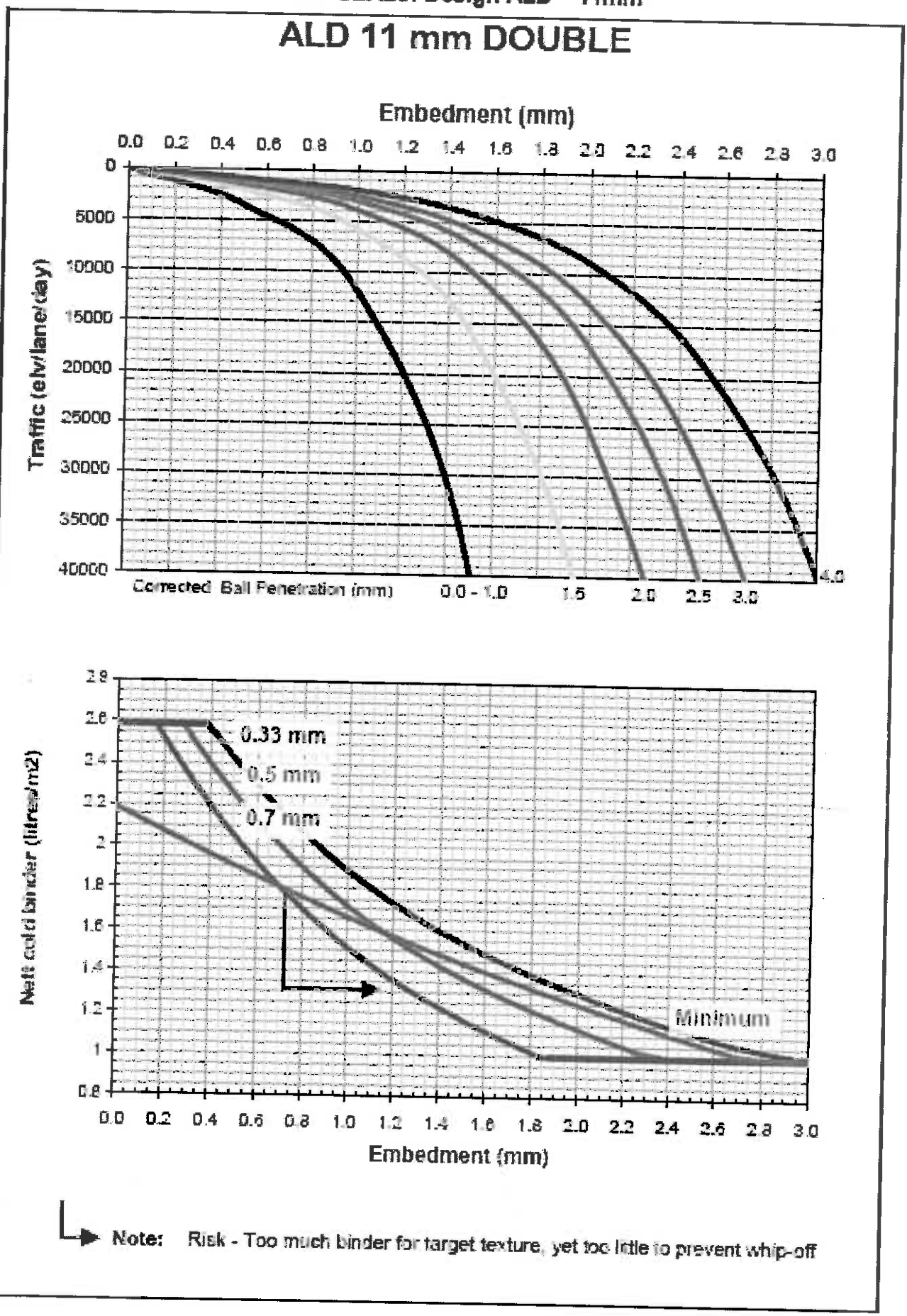


NB: Binder correction is in litres per square metre.

Table 7-3 - Factors for converting net cold residual binder to hot spray rates and storage and spraying temperatures

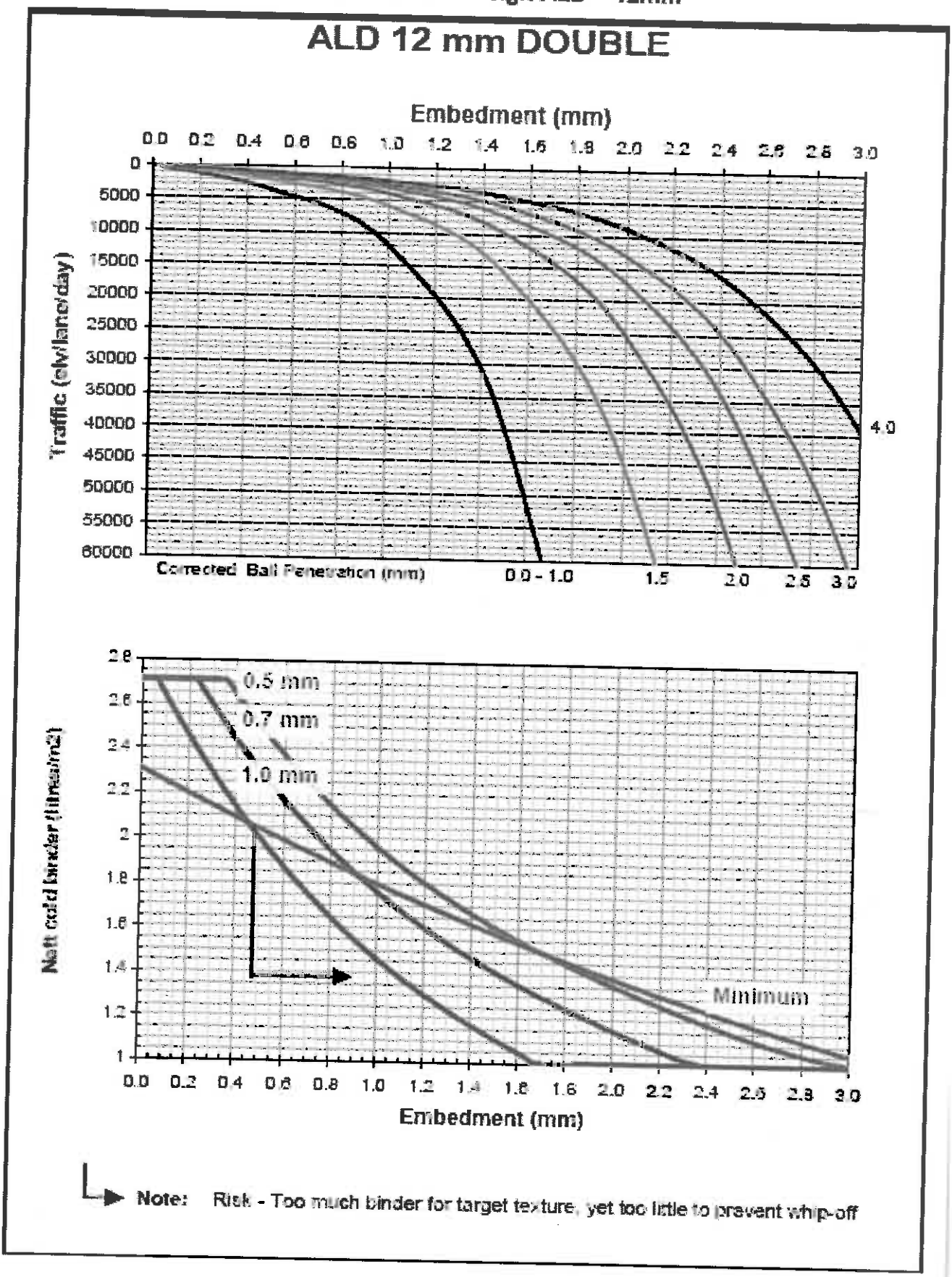
Type of binder	Conversion *** factor	Spray temperature (℃)	Max. storage temperature (℃)
Cutback bitumen			
MC 3000	1.19 – 1.27	130 - 155	100
MC 70	1.63 – 1.72	60 - 80	Ambient
MC 30	1.88 – 1.99	45 - 65	Ambient
Penetration grade bitumen			
150/200 pen	1.09	145 - 185	115
80/100 pen	1.09	160 - 200	125
Polymer modified bitumen			
S-E1	1.08	165 - 190	150
S-E2	1.06	165 - 190	150
Bitumen rubber (S-R1)	1.07	195 - 205	-
Bitumen emulsions			
60% emulsion	1.68	60	Ambient
65% emulsion	1.55	60	Ambient
70% emulsion	1.44	70	Ambient

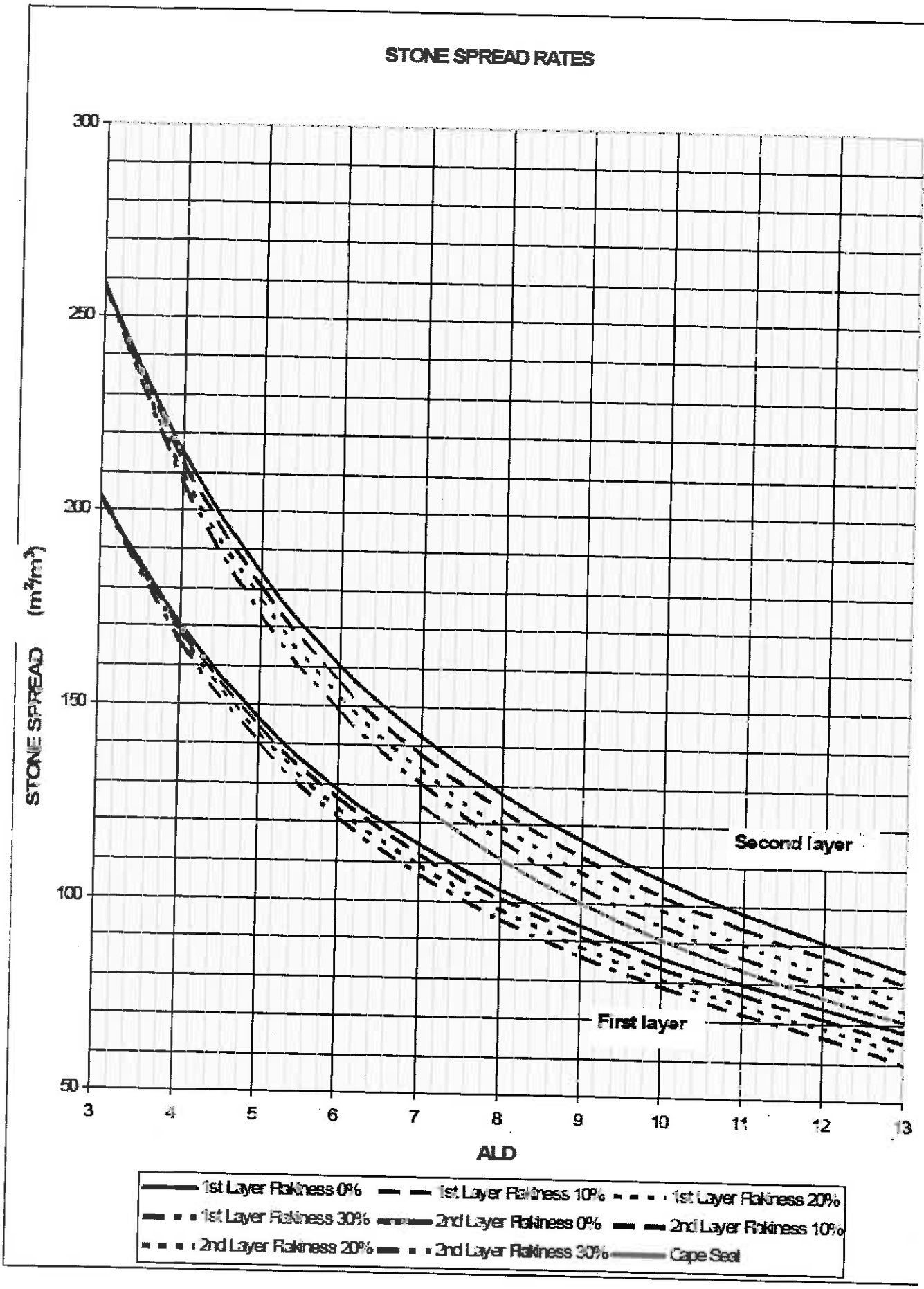
DESIGN CHART FOR DOUBLE SEALS: Design ALD = 11mm



Note: Risk - Too much binder for target texture, yet too little to prevent whip-off

DESIGN CHART FOR DOUBLE SEALS: Design ALD = 12mm




STONE SPREAD RATES
STONE SPREAD (m²/m²)
300
250
200
150
100
50
3
4
5
6
7
8
9
10
11
12
13
ALD
Second layer
First layer
1st Layer Rakiness 0%
1st Layer Rakiness 10%
1st Layer Rakiness 20%
1st Layer Rakiness 30%
2nd Layer Rakiness 0%
2nd Layer Rakiness 10%
2nd Layer Rakiness 20%
3nd Layer Rakiness 30%
Cape Seal