1-a). $T_{20} = (T_{air} - 0.00618\,Lat^2 + 0.2289\,Lat + 42.2) \cdot 0.9545 - 17.78$

$= (35 - 0.00618 \cdot 41.4^2 + 0.2289 \cdot 41.4 + 42.2) \cdot 0.9545 - 17.78$

$= 54.8$ ✓

For 98% reliability.

high temp: $\mu + 2\sigma = 54.8 + 2.2 = 58.8$ ✓

low temp: $\mu + 2\sigma = 20 + 2.4 = 28$ ✓

select PG 64-28. ✓

For design ESALs is between 10 to 30 million, so we chose binder PG 70-28 ✓ already no need

1-b. check the table, for 19mm NMS. $P_{bi} = 4.5\%$.

Use calculation.

a). $G_{se} = G_{sb} + 0.8(G_{sa} - G_{sb}) =$

Blend 1: $G_{se} = 2.758$ ✓

Blend 2: $G_{se} = 2.756$ ✓

Blend 3: $G_{se} = 2.751$ ✓

b). absorbed asphalt volume.

$V_{ba} = \dfrac{P_s(1 - V_a) \cdot \left(\frac{1}{G_{sb}} - \frac{1}{G_{se}}\right)}{\left(\frac{P_b}{G_b} + \frac{P_s}{G_{se}}\right)}$; first choose. $P_s = 95\%$. $P_b = 5\%$. $G_b = 1.02$. $V_a = 4\%$

Blend 1: $V_{ba} = \dfrac{0.95(1 - 0.04)}{\frac{0.05}{1.02} + \frac{0.95}{2.758}} \cdot \left(\frac{1}{2.704} - \frac{1}{2.758}\right) = 0.0168$ ✓

Blend 2: $V_{ba} = \dfrac{0.95 \cdot 0.96}{\frac{0.05}{1.02} + \frac{0.95}{2.756}} \cdot \left(\frac{1}{2.701} - \frac{1}{2.756}\right) = 0.0171$ ✓

Blend 3: $V_{ba} = \dfrac{0.95 \cdot 0.96}{\frac{0.05}{1.02} + \frac{0.95}{2.751}} \left(\frac{1}{2696} - \frac{1}{2.751}\right) = 0.0172$ ✓

c) $V_{be} = 0.081 - 0.02931 \cdot [\ln(S_n)]$

For blend 1, 2, 3. $V_{be} = 0.0894$ cm³/cm³ ✓

d): initial trial asphalt binder

$P_{bi} = \dfrac{G_b \times (V_{be} + V_{ba})}{G_b \times (V_{be} + V_{ba}) + W_s} \times 100\%$ $\qquad W_s = \dfrac{P_s \times (1 - V_a)}{\frac{P_b}{G_b} + \frac{P_s}{G_{se}}}$

Blend 1: $W_s = \dfrac{0.95 \times (1 - 0.04)}{\frac{0.05}{1.02} + \frac{0.95}{2.758}} = 2.718$ ✓

$P_{bi} = \dfrac{1.02 \times (0.0894 + 0.0168)}{[1.02 \times (0.0894 + 0.0168) + 2.718]} = 4.5\%$ ✓

(1)

Blend 2. $W_s = \frac{0.95 \times 0.96}{\frac{0.05}{1.013} + \frac{0.95}{2.756}} = 2.3\%$ ✓

$P_{bi} = \frac{(1.0\%) \times (0.089\% + 0.0171)}{(1.0\%) \times (0.089\% + 0.0171) + 2.416} = 4.5\%$ ✓

Blend 3: $W_s = \frac{0.95 \times 0.96}{\frac{0.05}{1.013} + \frac{0.95}{2.751}} = 2.313$ ✓

$P_{bi} = \frac{(1.0\%) \times (0.089\% + 0.0172)}{(1.0\%) \times (0.089\% + 0.0172) + 2.313} = 4.5\%$ ✓

1-c). For viscosity at 135 is 0.52 and at 165 is 0.17 pas.
the compaction temp is: 146 - 154 °C ✓
the mixing temp is: 161 - 168 °C ✓

1-d): ESALs = 25 million. N_{des} = 100. N_{ini} = 8.

Gmb for
Blend 1: Rep 1: 2.433; Rep 2: 2.436; average: 2.435
Blend 2: Rep 1: 2.441; Rep 2: 2.443; average: 2.442
Blend 3: Rep 1: 2.454; Rep 2: 2.462; average: 2.458

trial blend		% Gmm @ ini	% Gmm @ Ndes	% V_a	% VMA
Blend 1	Rep 1:	87.1	94.9 ✓	5.1	14.0
	Rep 2:	87.7	95.0	5.0	13.9
Blend 2	Rep 1	87.5	95.1	4.9	13.7
	Rep 2	87.0	95.1	4.9	13.7
Blend 3	Rep 1	89.0	95.9	4.1	13.1
	Rep 2	89.4	96.2	3.8	12.8

		P_b estimate: $= P_{bi} - 0.01(4 - V_a)$	% VMA estimate:	% VFA estimate	Gmm @ ini, estimate
Blend 1	Rep 1	4.9%	13.8%	71.0	88.2
	Rep 2	4.9%	13.7%	70.8	88.7
Blend 2	Rep 1	4.9%	13.5%	70.4	88.4
	Rep 2	4.9%	13.5%	70.4	87.9
Blend 3	Rep 1	4.5%	13.1%	69.5	89.1
	Rep 2	4.4%	12.8%	68.8	89.2

$DP = \frac{P_{a,23}}{P_{be,estimate}}$. $P_{be,estimate} = -(P_a \times G_b) \times \frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} + P_{b,estimate}$.

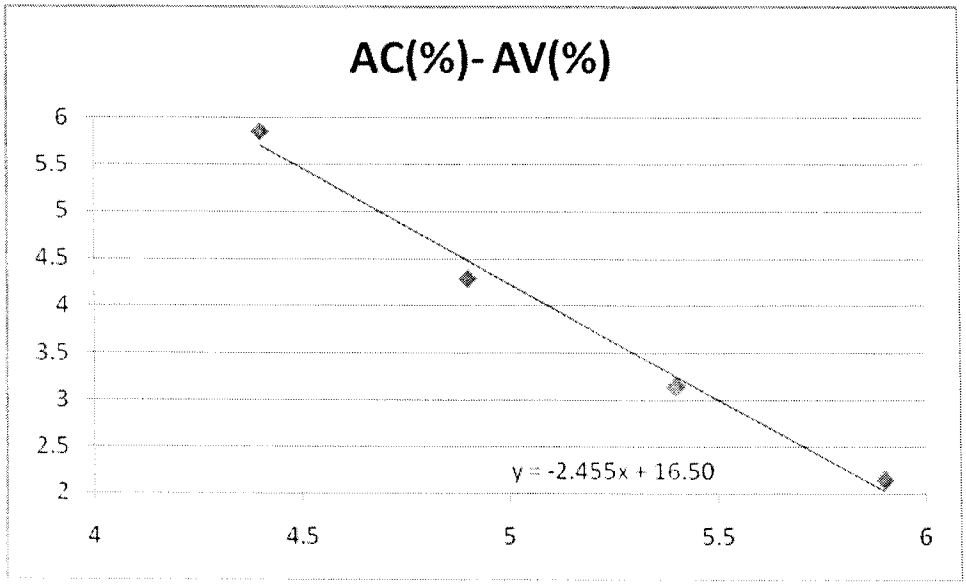
		$P_{be,estimate}$,	DP.
Blend 1.	Rep 1	4.2 ~~3.8%~~	0.~~82~~ 0.85)
	Rep 2	4.1 ~~3.8%~~	~~0.82~~ 0.85)
Blend 2	Rep 1	4.2%	0.824
	Rep 2	4.2%	0.824
Blend 3	Rep 1	3.8%	1.08
	Rep 2.	3.7%	1.11

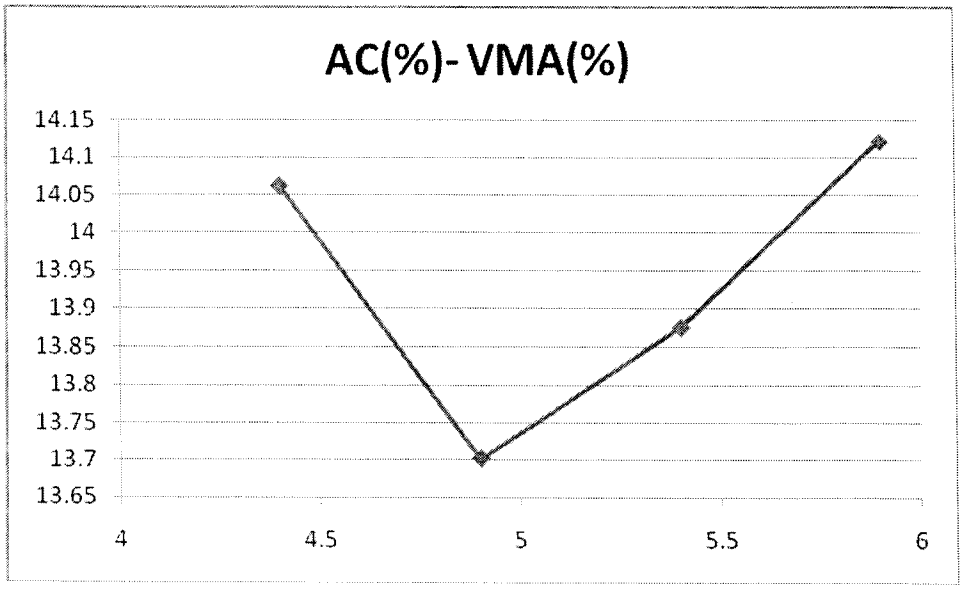
Summary:		AC%	EstAC%	%AV	%UHA	%UFA	DP	%Gum @ min
Blend 1	Rep 1	~~4.5%~~ 4.5%	~~4.8%~~ 4.8%	~~5%~~ 4%	14.0	71.0	0.85)	88.2
	Rep 2	~~4.5%~~ 4.5%	4.8%	~~4%~~ 4%	13.8	70.8	0.85)	88.0
Blend 2	Rep 1	~~4.5%~~ 4.5%	4.8%	~~4%~~ 4%	13.0	70.4	0.824	88.4
	Rep 2	~~4.5%~~ 4.5%	4.8%	~~4%~~ 4%	13.0	70.4	0.824	87.8
Blend 3	Rep 1	~~4.5%~~ 4.5%	4.5%	~~4%~~ 4%	13.1	69.5	1.08	89.1
	Rep 2	~~4.5%~~ 4.5%	4.6%	~~4%~~ 4%	12.8	68.8	1.11	89.2
Specification:				4	~~4~~ >13%	~~65~~ 65-75%	0.8-1.2	<89

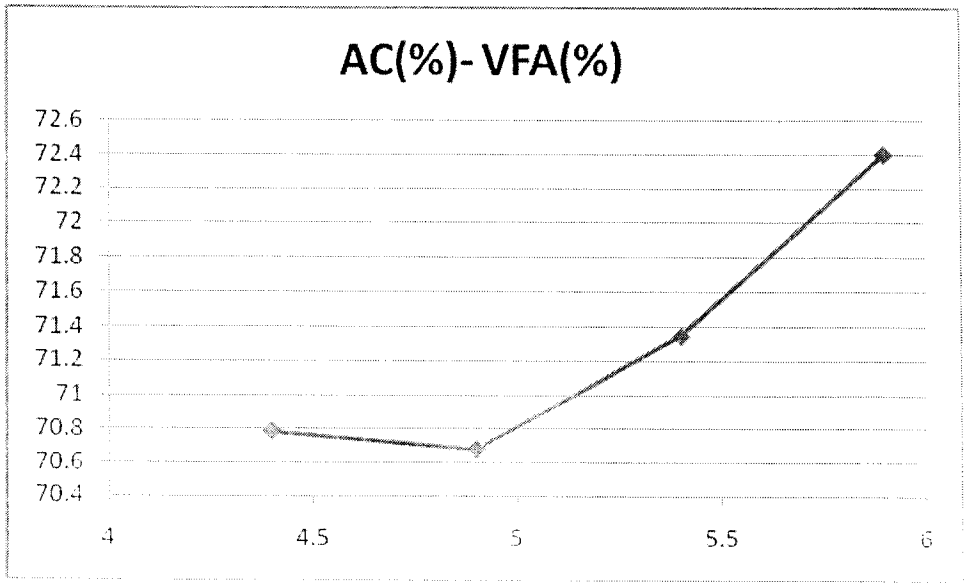
Blend 3 does not satisfy specification. Here use blend 2.

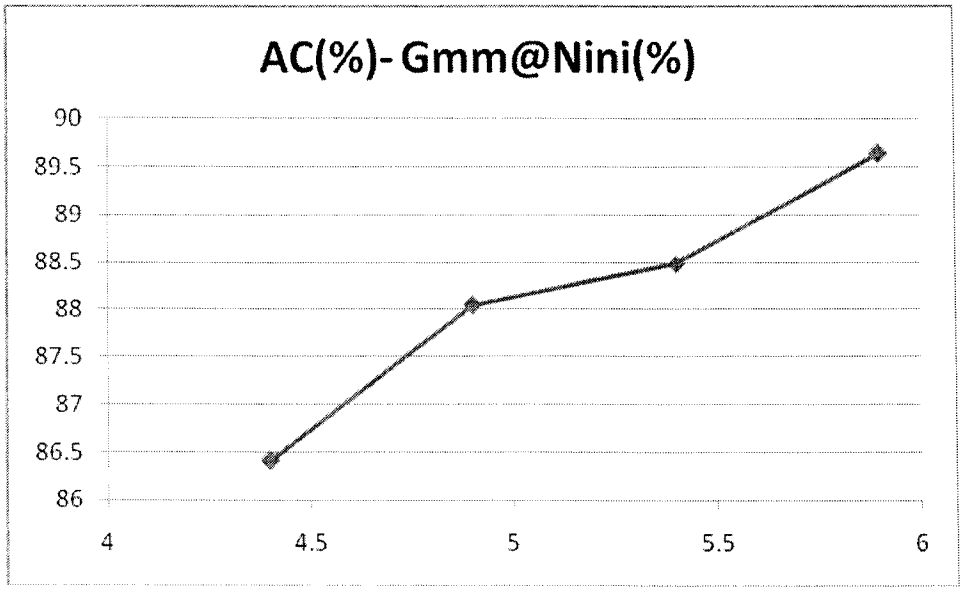
2

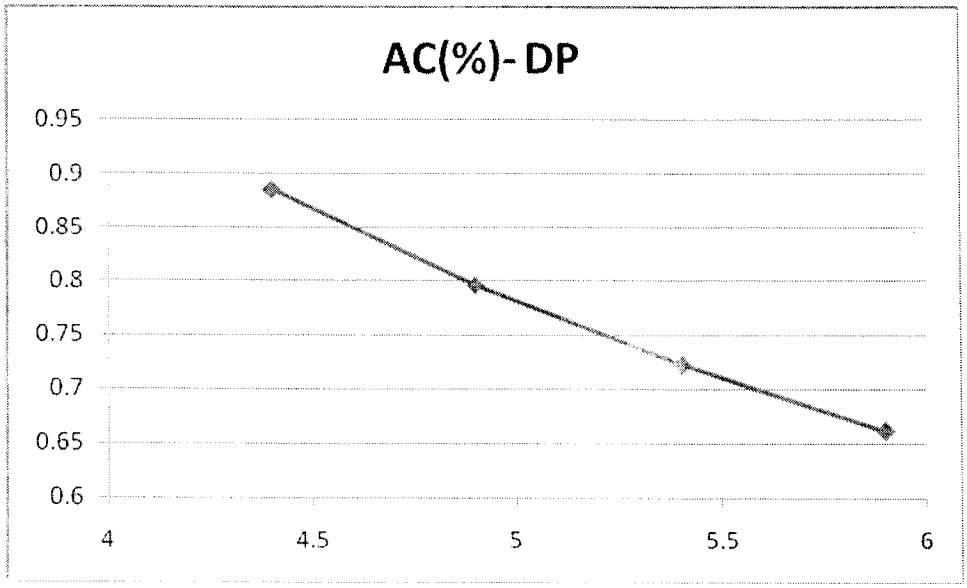
height@8	125.4	124.9	126.2	126.3
height@100	115.1	114.9	115.3	115.7
Gmb	2.428	2.451	2.459	2.465
Gmm	2.579	2.561	2.539	2.519
AC(%)	4.4	4.9	5.4	5.9
AV(%)	5.854982551	4.2951972	3.15084679	2.1437078
Gmm@Nini(%)	86.41221299	88.042289	88.4842105	89.643492
Gmm@Ndes(%)	94.14501745	95.704803	96.84915321	97.856292
VMA(%)	14.06264347	13.702295	13.87582377	14.121992
VMAest(%)	13.69164696	13.643256	13.96073909	14.49325
VFA(%)	70.78510706	70.681485	71.34822179	72.400946
DP	0.886363636	0.7959184	0.722222222	0.6610169
Gsb	2.701	2.701	2.701	2.701




AC(%)- VMA(%)
14.15
14.1
14.05
14
13.95
13.9
13.85
13.8
13.75
13.7
13.65
4
4.5
5
5.5
6


AC(%)- VFA(%)
72.6
72.4
72.2
72
71.8
71.6
71.4
71.2
71
70.8
70.6
70.4
4
4.5
5
5.5
6





B) Use equation y = -2.4556x + 16.508 we can get the optimum asphalt content
4= -2.4556x + 16.508 so x=5.1 That is asphalt content is 5.1%

C) When asphalt content is 5.1%, VMA=13.8, VFA=71.1 Gmm@Nini(%)=88.2, DP=0.76. All satisfy the specifications.

3. $R = \frac{2P}{\pi D t}$

$R_1 = 0.84$ $R_2 = 0.846$ $R_3 = 0.885$

$R_4 = 0.715$ $R_5 = 0.692$ $R_6 = 0.702$

$$TSR = \frac{(R_4 + R_5 + R_6)/3}{(R_1 + R_2 + R_3)/3} = 81.4\% > 80\%$$

Satisfy AASHTO T-283