CIVIL ENGINEERING

Highway Laboratory

Experiment title:

Marshall Mix Design

Student's Name: عمر زياد وزيد ابوزياد

Student's ID. No.: 1432740

Sec#: 1 Day: الاحد

Abbreviations and Equations

LIST OF ABBREVIATIONS	
G_{se}	Effective specific gravity of aggregate coated with asphalt
$G_{mm\ exp}$	Theoretical maximum specific gravity
G_b	Specific gravity of the asphalt binder
Gsb	Bulk specific gravity of aggregate
Gmb	Bulk specific gravity of the compacted specimen
$G_{mm,cal}$	Theoretical maximum specific gravity of asphalt concrete
AV% or (VTM)	Percent of air voids in the compacted bitumen paving mixture
VMA%	Voids in mineral aggregate (AV + volume of effective asphalt)
VFA%	Voids filled with asphalt
P_s	Percent weight of aggregate
P_b	Percent weight of the asphalt cement

LIST OF EQUATIONS	
Gmb	$A/(B-C)$
$Gmm_{,cal}$	$G_{mm} = \frac{100}{\left(\frac{P_s}{G_{se}} + \frac{P_b}{G_b}\right)}$
AV%	$[1 - \frac{Gmb}{Gmm}] * 100$
VMA	$[1 - \frac{Gmb(1-Pb)}{Gsb}] * 100$
VFA	$[\frac{VMA - AV}{VMA}] * 100$

Note: All calculations should be to two decimal places

2. Theoretical Maximum Specific Gravity Gmm.

Calculated from loose sample at optimum asphalt content

A: Wt. of sample (g)	D: Wt. of Pycnometer filled with water (g)	E: Wt. of Pycnometer filled with sample and water (g)	Gmm: exp. Maximum Theoretical Specific Gravity
1158	7652	8331	2.418

$$Gmm = \frac{A}{A+D-E}$$

3. Effective Specific Gravity for Aggregate

Calculated at optimum asphalt content.

$$Gse = \frac{Pmm - Pb}{\frac{Pmm}{Gmmexp} - \frac{Pb}{Gb}}$$

$$= \frac{100 - 4}{\frac{100}{2.418} - \frac{4}{1.01}} = 2.567$$

Marshall Table

Gb	1.01

Gsb	2.65

ρw	1000 kg/m³

$G_{se} = 2.567$

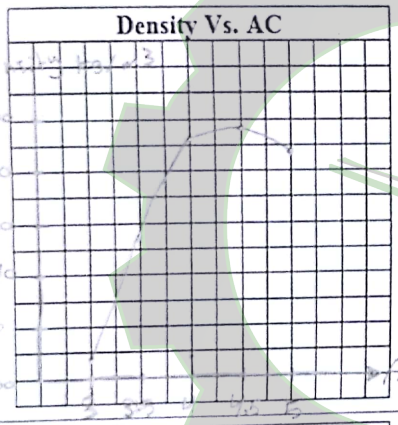
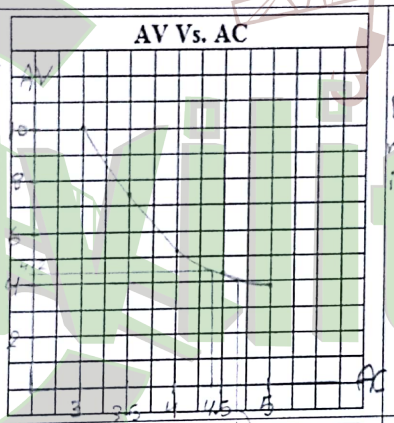
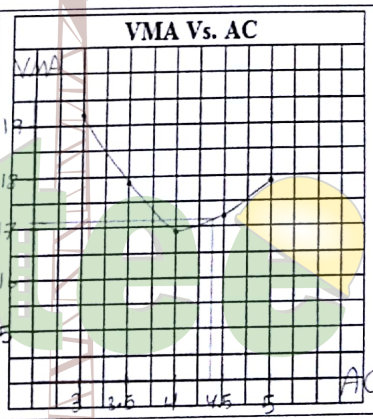
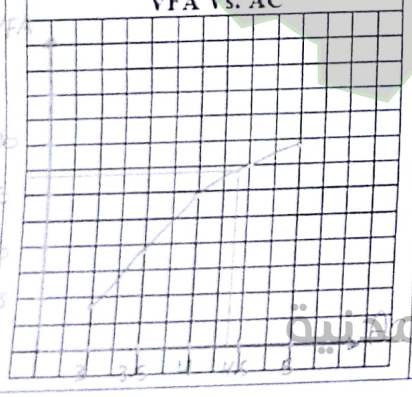
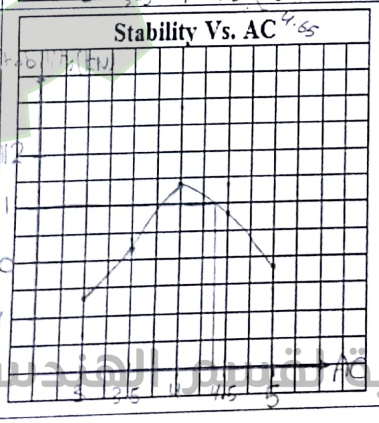
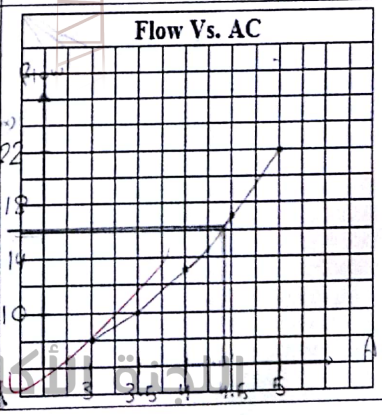
AC %	Wt in air (g)	Wt SSD (g)	Wt in water (g)	Gmb	Mix Density (Kg/m³)	Gmm_{cal}	AV %	VMA %	VFA %	Stability (KN)	Flow (0.25mm)
3.0	1235.5	1262.3	702.5	2.207	2207	2.454	10.07	19.22	47.61	9.3	8
3.5	1243.2	1271.6	720.3	2.255	2255	2.436	7.43	17.85	58.45	10.2	10
4.0	1248.2	1261.2	716.9	2.293	2293	2.418	5.17	16.93	69.46	11.4	13
4.5	1255.6	1267.6	720.9	2.297	2297	2.400	4.29	17.22	75.09	10.7	17
5.0	1259.7	1271.3	721	2.289	2289	2.383	3.94	17.94	78.04	9.7	22

5. Sample of Calculation

Gmb	Gmm_{cal}	AV %	VMA %	VFA %
$G_{mb} = \frac{\text{Wt in air}}{W_{SSD} - W_{inw}}$ $= \frac{1235.5}{1262.3 - 702.5}$ $= 2.207$	$G_{mm} = \frac{100}{\left(\frac{P_s}{G_{se}} + \frac{P_b}{G_b}\right)}$ $= \frac{100}{\left(\frac{97}{2.567} + \frac{3}{1.01}\right)}$ $= 2.454$	$AV\% = \left[1 - \frac{G_{mb}}{G_{mm}}\right] * 100$ $= \left(1 - \frac{2.207}{2.454}\right) * 100$ $= 10.07\ \%$	$VMA = \left[1 - \frac{G_{mb}(1-P_b)}{G_{sb}}\right] * 100\%$ $= \left[1 - \frac{2.207(1-0.03)}{2.65}\right] * 100$ $= 19.22\ \%$	$VFA = \frac{VMA - AV}{VMA} * 100$ $= \frac{19.22 - 10.07}{19.22} * 100$ $= 47.61\ \%$

Plots and Comments

Plot AC Content Vs. Density, AV, VMA, VFA, Stability and Flow and comment on the relations

Density Vs. AC	Relation	AV Vs. AC	Relation	VMA Vs. AC	Relation
	non-linear increase and after the AC% = 4.5 (max) start to Decrease		Decrease non-linear inverse		non-linear Decrease and after AC = 4 (min) start to increase
VFA Vs. AC	**Relation**	**Stability Vs. AC**	**Relation**	**Flow Vs. AC**	**Relation**
	direct non-linear		increase until AC = 4 (max) then decrease non-linear		non-linear direct

Finding Optimum AC Content

Show your values clearly on the graphs

7.1 Determine the optimum asphalt content from curves, which yield the maximum density, maximum stability and 4% AV.

Hint:
Nominal Maximum Particle Size=3/8 in
Compare to Medium Traffic.

	Max Density	Max Stability	4% AV	Average
AC%	4.5 %	4 %	4.65 %	4.38 %

Avg = $\frac{4.5+4+4.65}{3} = 4.38$

mention -0.5

	Value (Using the curves, at avg. of AC %)	Within the specification or not
AV	4.2 %	ok ✓
VMA	17.2 %	ok ✓
VFA	74 %	ok ✓
Stability	11 kN	ok ✓
Flow	16.1	not ok

TABLE 9.13 Asphalt Institute Criteria for Marshall Mix Design (The Asphalt Institute, 1995)

	Traffic Level					
	Light		Medium		Heavy	
Compaction (blows)	35		50		75	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Stability, kN	3.34	—	5.34	—	8.01	—
Flow, 0.25 mm	8	18	8	16	8	14
Air Voids, %	3	5	3	5	3	5
VMA, %	Use the criteria in Table 9.14					
VFA, %	70	80	65	78	65	75

TABLE 9.14 Minimum Percent Voids in Mineral Aggregate (VMA) (The Asphalt Institute, 1995)

Nominal Maximum Particle Size[1]	Minimum VMA, Percent Design Air Voids[2]		
	3.0	4.0	5.0
2.36 mm (No. 8)	19.0	20.0	21.0
4.75 mm (No. 4)	16.0	17.0	18.0
9.5 mm (3/8 in.)	14.0	15.0	16.0
12.5 mm (1/2 in.)	13.0	14.0	15.0
19.0 mm (3/4 in.)	12.0	13.0	14.0
25.0 mm (1.0 in.)	11.0	12.0	13.0

CIVIL ENGINEERING

California Bearing Ratio Test (CBR)

Student name: عمر زياد فريد ابوزياد

ID#: 1432740

Section: 1

14.5/15

1. Fill the Tables

Note: The answers must be to the nearest two decimal places

Table 01: Soaked and Un-soaked CBR Densities Data and Results

No .of Blows per Layer	12	26	56
Empty Mold Weight (Kg)	14.94	14.84	14.75
Weight of Mold + soaked soil (Kg)	18	19	21
Water Content after soaking%	19	23	28
Mold Volume (cm3)	2305		
Bulk Densities (g/cm3)	1.33	1.8	1.71
Dry Densities (g/cm3)	1.12	1.46	2.12

Table 02: Mold Stress Data and CBR Results

Penetration (mm)	Load (KN)			Stress (Mpa)			CBR %		
	Mold 1	Mold 2	Mold 3	Mold 1	Mold 2	Mold 3	Mold 1	Mold 2	Mold 3
0.0	0.00	0.00	0.00	0	0	0			
0.5	0.20	0.50	1.00	0.1	0.26	0.52			
1.0	0.40	0.80	1.40	0.21	0.41	0.72			
1.5	0.50	1.10	1.81	0.26	0.57	0.94			
2.0	0.60	1.20	2.03	0.31	0.62	1.05			
2.5	0.79	1.30	2.20	0.41	0.67	1.14	5.94	9.71	16.52
3.0	0.80	1.40	2.34	0.41	0.72	1.21			
3.5	0.91	1.50	2.53	0.47	0.78	1.31			
4.0	0.99	1.59	2.66	0.51	0.83	1.38			
4.5	1.06	1.65	2.80	0.55	0.85	1.45			
5.0	1.13	1.70	2.90	0.58	0.88	1.5	5.63	8.54	14.56
5.5	1.19	1.80	3.03	0.61	0.93	1.57			
6.0	1.26	1.90	3.13	0.65	0.98	1.62			
6.5	1.31	2.00	3.21	0.68	1.03	1.66			
7.0	1.37	2.10	3.29	0.71	1.09	1.7			
7.5	1.42	2.20	3.36	0.73	1.14	1.74			
						CBR	5.94	9.71	16.52

Hint: Piston area=1935mm²

- Bulk Density = $\frac{\text{wt. Soil}}{\text{Volume}} = \frac{\text{wt(mold + Soil)} - \text{wt(mold)}}{\text{Volume}}$

$= \frac{(18 - 14.94) * 1000}{2305} = 1.33 \text{ g/cm}^3$ (for 12 blows)

- dry density = $\frac{\text{Bulk density}}{1 + \text{wc \%}} = \frac{1.33}{1+0.19} = 1.12 \text{ g/cm}^3$ (for 12 blows)

* For mold ② @ 2.5 mm penetration :

Stress = $\frac{\text{Load}}{\text{Area of piston}} = \frac{2.3 * 1000}{1935} = \boxed{0.67 \text{ Mpa}}$

CBR = $\frac{\text{Unit Load @ 2.5 mm}}{6.9 \text{ MPa}} = \frac{0.67}{6.9} = 0.971 * 100\% = \boxed{9.71\%}$

* For mold ② @ 5 mm penetration :

Stress = $\frac{1.7}{1935} = \boxed{0.88 \text{ Mpa}}$

CBR = $\frac{0.88}{10.3} * 100\% = \boxed{14.56\%}$

∴ CBR @ 2.5 mm = 9.71 % > CBR @ 5 mm = ~~14.56~~ 8.54 %.

So, $\boxed{\text{CBR} = 9.71\%}$

3. Plot (no excel is allowed)
   3.1 stress in piston vs. Penetration for three molds on the same graph.
   3.2 CBR vs. Dry densities.

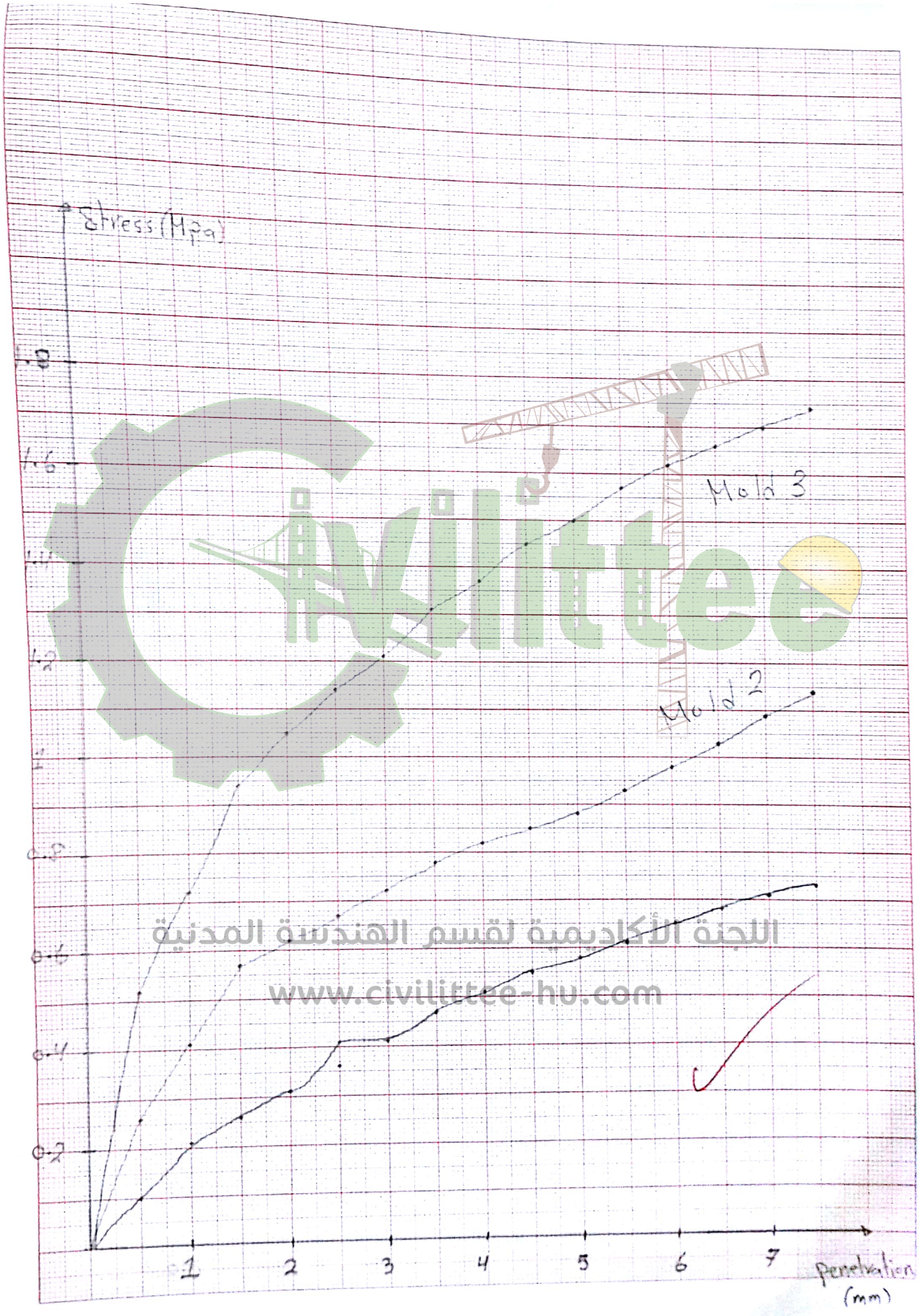
4.1 Comment on the graph no.1 (relation between stress and penetration for the three molds)

- the relation between stress & penetration is direct and non-Linear
- The Curves are smooth
- there is no correction for any curves because they are Concave down in the first portion also no curves are Concave up and that may be happen due to surface irregularity.

4.2 comment on the graph no.2 (CBR vs. Dry densities)

- non-Linear and Direct relation (CBR ↑ → dry density ↑)
- the relation between Compaction and Values of CBR is direct, which is because increasing the # of blows will increase the compactiability of the sample (more compacted sample) and dry density will also increase so CBR increase.
- we don't need to repeat the test due that the Values of CBR @2.5mm > CBR @5mm

yes ok



CIVIL ENGINEERING

Highway Laboratory

Experiment title:

Aggregate Blending to meet Specifications

Student's Name: عمر زياد فريد ابو زياد

Student's ID. No.: 1432740

Sec#: 1 Day: الاحد

15/15

Thanks

1. Sieve Analysis Data and Results

Note: all calculations should be to two decimal places

Table 01: Sieve Analysis for Aggregate A, Cumulative Percent Passing For Aggregates B and C.

Sieve No.	Sieve opening mm	Sieve opening ^0.45	Retained Kg			Retained %			Cumulative Retained %			Cumulative Passing %		
			A	B	C	A	B	C	A	B	C	A	B	C
1"	25	4.26	0.00	0.00	0.00	0	0	0.00	0	0	0.00	100	100	100.00
3/4"	19	3.76	0.43	0.00	0.00	17	0	0.00	17	0	0.00	83	100	100.00
1/2"	12.5	3.12	0.87	0.13	0.00	34.39	4.56	0.00	51.38	4.56	0.00	48.62	95.44	100.00
3/8"	9.5	2.75	0.22	0.16	0.00	8.7	5.61	0.00	60.08	10.18	0.00	39.92	89.82	100.00
#4	4.75	2.02	0.47	0.19	0.00	18.58	6.67	0.00	78.66	16.84	0.00	21.34	83.16	100.00
#8	2.38	1.48	0.07	1.27	0.01	2.77	44.56	0.01	81.42	61.4	1.42	18.58	38.6	98.58
#20	1.19	1.08	0.07	0.26	0.39	2.77	9.12	0.39	84.19	70.53	70.27	15.81	29.47	29.73
#50	0.3	0.58	0.10	0.42	0.12	3.95	14.74	0.12	88.14	85.26	91.33	11.86	14.74	8.67
#100	0.15	0.43	0.10	0.12	0.01	3.95	4.21	0.01	92.09	89.47	92.21	7.91	10.53	7.79
#200	0.075	0.31	0.10	0.18	0.01	3.95	6.32	0.01	96.05	95.79	94.34	3.95	4.21	5.66
pan			0.10	0.12	0.03	3.95	4.21	0.03	100	100	100.00	0	0	0.00
			Sum											
			2.53	2.85	0.57									

2. Aggregate Blending Results

2.1 For three Aggregate Blend:

- Two trials are required for the three aggregates blend, one with the initial guess from critical sieves, the other with the final percentages used.
- Your remarks should include "ok", reject or "improve".
- The final trial should be all of "ok" remark.

Table 02: Aggregate Blending For Three Aggregate Calculations

Aggregate	Percent used	1"	3/4"	1/2"	3/8"	#4	#8	#16	#50	#100	#200
A	Original	100		48.62	39.92	21.34	18.58	15.81	11.86	7.91	3.95
B	Original	100		96.44	89.82	83.16	38.6	29.47	14.74	10.53	4.21
C	Original	100.00	100.00	100.00	100.00	100.00	98.58	29.73	8.67	7.79	5.66
Specification	Upper	100	100	80	70	55	43	30	20	15	8
	Lower	100	85	68	52	35	23	14	5	5	1
	Median	100	92.5	74	61	45	33	22	12.5	10	4.5
Aggregate	Initial guess%	First Trial									
A	44.1	44.1	36.6	21.44	17.61	9.41	8.19	6.97	5.23	3.49	1.74
B	20.3	20.3	20.3	19.37	18.23	16.88	7.84	5.98	2.99	2.14	0.85
C	35.6	35.6	35.6	35.6	35.6	35.6	35.09	10.58	3.09	2.77	2.01
Blend		100	92.5	76.41	71.44	61.89	51.12	23.54	11.31	8.4	4.61
Remark		ok	ok	ok	R	R	R	ok	ok	ok	ok
Aggregate	Final guess%	Final Trail									
A	56	56	46.48	27.23	22.36	11.95	10.4	8.85	6.64	4.43	2.21
B	25.5	25.5	25.5	24.32	22.9	21.21	9.84	7.51	3.77	2.68	1.07
C	18.5	18.5	18.5	18.5	18.5	18.5	18.24	5.5	1.6	1.44	1.05
Blend		100	90.48	70.06	63.76	51.66	38.48	21.86	12	8.55	4.33
Remark		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok

2.2 For two Aggregate Blend:

- Choose two aggregates that will meet the specifications.
- The Blend remarks should be of "ok" remark

Table 03: Aggregate Blending For Two Aggregate Calculations

Aggregate	Percent used	1"	3/4"	1/2"	3/8"	#4	#8	#16	#50	#100	#200
A	Original	100	83	48.62	39.92	21.34	18.58	15.81	11.81	7.91	3.95
C	Original	100	100	100	100	100	98.58	29.73	8.67	7.79	5.66
Specification	Upper	100	100	82	80	65	49	43	32	25	12
	Lower	100	80	60	41	29	23	14	5	4	1
	Median	100	90	71	60.5	47	36	28.5	18.5	14.5	6.5
Aggregate	Final guess%	Final Trail									
A	71	71	58.93	34.52	28.34	15.15	13.19	11.23	8.39	5.62	2.8
C	29	29	29	29	29	29	28.59	8.62	2.61	2.26	1.64
Blend		100	87.93	63.52	57.34	44.15	41.78	19.85	10.9	7.88	4.45
Remark		ok	ok	ok	ok	ok	ok	ok	ok	ok	ok

3. Sample of Calculations:

3.1 No Sample of calculations is needed for sieve analysis, only fill the table.

3.2 Put a detailed sample of calculations of the way finding the initial guess of aggregate percentages. **Mention your critical sieve.**

Critical sieve 1: 3/4"

Critical sieve 2: #4

$\%A = \frac{7.5\%}{17\%} = 44.1\%$

$\%B = 55\% - 0.441 * 78.66 = 20.3\%$

$\%C = 100\% - 44.12\% - 20.3\% = 35.6\%$

4. Plot

4.1 For Three Aggregates Blend: Plot Percent Cumulative Passing for original Aggregates A, B, C and the final accepted Blend