Practice Problems

Section 15 – Practice Problems

Practice Problems

- Compaction Pay Factors
- Cost Analysis
- Cores vs. Nuclear Testing Correlation
- Density Random Number Selection
- Compaction Pay Factors-SD

Pay Factor Determination (p. 15-3)

- **Density**
  - Determine core densities
    - WYDOT MTM 415.0
    - Round to 0.01%
  - Determine % density

$$\% \text{ Density} = \frac{\text{density}}{\text{max. theor.}} = x$$

  - Determine average ($\overline{x}$)

$$\overline{x} = \frac{\Sigma x}{n}$$

Pay Factor Determination (p. 15-4)

- **Determine standard deviation (s)**

$$s = \sqrt{\left(\frac{1}{n-1}\right)\sum\left(x-\bar{x}\right)^2}$$

  - **Calculate the Quality Index (QI)**

$$\text{Upper Quality Index} = Q_u = \frac{SL_u - \bar{x}}{s}$$

$$\text{Lower Quality Index} = Q_l = \frac{\bar{x} - SL_l}{s}$$

  - **Where:**

SL_U = 100

SL_L = 92

n = 7

  - **For PF < 0.75 Remove and Replace**

Pay Factor Determination (p. 15-5) Table 113.1-1

Table 113.1-1
Quality Level Analysis by the Standard Deviation Method

PU or PL percent Within Limits for Positive Values of QU or QL	Upper Quality Index QU or Lower Quality Inex QL				
	n = 3	n = 4	n = 5	n = 6	n = 7
100	1.16	1.50	1.79	2.03	2.23
99		1.47	1.67	1.80	1.89
98	1.15	1.44	1.60	1.70	1.76
97		1.41	1.54	1.62	1.67
96	1.14	1.38	1.49	1.55	1.59
95		1.35	1.44	1.49	1.52
94	1.13	1.32	1.39	1.43	1.46
93		1.29	1.35	1.38	1.40
92	1.12	1.26	1.31	1.33	1.35
91	1.11	1.23	1.27	1.29	1.30
90	1.10	1.20	1.23	1.24	1.25
89	1.09	1.17	1.19	1.20	1.20
88	1.07	1.14	1.15	1.16	1.16
87	1.06	1.11	1.12	1.12	1.12
86	1.04	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.04	1.04
84	1.01	1.02	1.01	1.01	1.00
83	1.00	0.99	0.98	0.97	0.97
82	0.97	0.96	0.95	0.94	0.93
81	0.96	0.93	0.91	0.90	0.90
80	0.93	0.90	0.88	0.87	0.86
79	0.91	0.87	0.85	0.84	0.83
78	0.89	0.84	0.82	0.80	0.80
77	0.87	0.81	0.78	0.77	0.76
76	0.84	0.78	0.75	0.74	0.73
75	0.82	0.75	0.72	0.71	0.70
74	0.79	0.72	0.69	0.68	0.67
73	0.76	0.69	0.66	0.65	0.64

Pay Factor Determination (p. 15-6) Table 113.1-1

Table 113.1-1
Quality Level Analysis by the Standard Deviation Method

PU or PL percent Within Limits for Positive Values of QU or QL	Upper Quality Index QU or Lower Quality Inex QL				
	n = 3	n = 4	n = 5	n = 6	n = 7
72	0.74	0.66	0.63	0.62	0.61
71	0.71	0.63	0.60	0.59	0.58
70	0.68	0.60	0.57	0.56	0.55
69	0.65	0.57	0.54	0.53	0.52
68	0.62	0.54	0.51	0.50	0.49
67	0.59	0.51	0.47	0.47	0.46
66	0.56	0.48	0.45	0.44	0.44
65	0.52	0.45	0.43	0.41	0.41
64	0.49	0.42	0.40	0.39	0.38
63	0.46	0.39	0.37	0.36	0.35
62	0.43	0.36	0.34	0.33	0.32
61	0.39	0.33	0.31	0.30	0.30
60	0.36	0.30	0.28	0.27	0.27
59	0.32	0.27	0.25	0.25	0.24
58	0.29	0.24	0.23	0.22	0.21
57	0.25	0.21	0.20	0.19	0.19
56	0.22	0.18	0.17	0.16	0.16
55	0.18	0.15	0.14	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11
53	0.11	0.09	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00

Note: If the value of Q_U or Q_L does not correspond exactly to a figure in the table, use the next highest figure. For values of Q_U or Q_L less than zero, use the absolute value of the calculated Q_U or Q_L to determine the corresponding value for P_U or P_L. The actual value of P_U or P_L equals 100 minus the table value for P_U or P_L.

Pay Factor Determination (p. 15-7)

➢ Determine PWL(Density) (Quality Level)

$$\text{quality level} = (P_U + P_L) - 100$$

▸ Calculate the Pay Factor(Density)

$$PF_D = 0.55 + 0.50 \times \frac{PWL_D}{100}$$

▸ Where:

PF_D	=	pay factor for in-place density, rounded to the nearest 0.0001
PWL_D	=	percent within limits for in-place density

Compaction Pay Factors

1. 94.3% 95.80% 94.70% 95.00% 95.60% 95.2% 94.90%

x = 95.07
s = 0.52

Qu = 9.48
Ql = 5.90
PU = 100 from Table (113.1-1)
PL = 100 from Table (113.1-1)
Quality Level = 100
PFD = 1.05

2. 95.7% 92.90% 92.80% 92.00% 95.40% 93.60% 93.50%

x = 93.70
s = 1.37

Qu = 4.60
Ql = 1.24
PU = 100 from Table (113.1-1)
PL = 90 from Table (113.1-1)
Qualit y Level = 90
PFD = 1.0

3. 98.80% 98.2% 98.00% 98.90% 96.80% 92.30% 90.20%

x = 96.17
s = 3.48

Qu = 1.10
Ql = 1.20
PU = 87 from Table (113.1-1)
PL = 89 from Table (113.1-1)
Quality Level = 76
PFD = 0.93

4. 92.60% 90.70% 91.90% 93.40% 92.10% 91.00% 90.90%

x = 91.8
s = 1.00

Qu = 8.20
Ql = -0.20
PU = 100 from Table (113.1-1)
PL = 42
Quality Level = 42
PFD = 0.76

Cost Analysis

Example #1

Material	% of Total Mix	Cost/Ton
Aggregate #1	45	$7.50
Aggregate #2	33	$6.65
Aggregate #33	16	$5.50
Asphalt	6	$120

45% x $7.50 or 0.45 x 7.50 = 3.38
33% x $6.65 or 0.33 x 6.65 = 2.19
16% x $5.50 or 0.16 x 5.50 = 0.88
6% x $120 or 0.06 x 120 = 3.38

$13.65 per mix ton

Density = 155 pcf

Pavement Thickness = 4.5 inches

Compute the Following:

1. Mix Cost per Ton
2. Cost per Cubic Yard
3. Cost per Square Yard

$$\frac{\$}{yd^3} = \frac{\$13.65}{ton} \; x \frac{155\ lb}{ft^3} x \frac{1\ ton}{2000\ lb} x \frac{27\ ft3}{yd^3} = \$28.56/yd^3$$

$$\frac{\$}{yd^2} = \frac{\$28.56}{yd^3} \; x\ 4.5\ in\ x \frac{1\ yd}{36\ in} = \$3.57/yd^2$$

Cost Analysis

Example #2

Solution:

Mix Cost per Ton = $25.00

Density = 150 pcf

Pavement Thickness = 5 in

Compute the Following:

1. Cost per Cubic Yard
2. Cost per Square Yard

$$\frac{\$}{yd^3} = \frac{\$25.00}{ton} \; x \frac{150\ lb}{ft^3} x \frac{1\ ton}{2000\ lb} x \frac{27\ ft3}{yd^3} = \$50.63/yd^3$$

$$\frac{\$}{yd^2} = \frac{\$50.63}{yd^3} \; x\ 5.0\ in\ x \frac{1\ yd}{36\ in} = \$7.03/yd^2$$

Table (MTM417.0) (p. 15-9)

Grading (Nominal Max. Size)					
	1”	3/4”	1/2”	3/8”	PMWC
Sieve	Allowable Difference (% Passing)				
1 ¼”	1.5				
1”	2	1.5			
¾”	3	2	1.5		
½”	3.4	3	2	1.5	1.5
3/8”	3.4	3.4	3.4	2	2
No. 4	3.4	3.4	3.4	3.4	3.4
No. 8	3.3	3.3	3.3	3.3	3.3
No. 30	2.9	2.9	2.9	2.9	
No. 200	1.2	1.2	1.2	1.2	1.2

Verification Testing (Aggregate Gradation)

Problem #1

See Section 9-33 Table (MTM417.0)

A Contractor Obtained the Following Gradation for an Aggregate Sample:

Sieve Size	% Passing
1"	100
3/4"	95
1/2"	75
3/8"	68
#4	52
#8	41
#30	27
#200	5.2

For 3/4" size 95% – 94% = 1% **Ok (1≤ 2)**

For 1/2" size 75% – 72% = 3% **Ok (3≤ 3)**

For 3/8" size 68% – 65% = 3% **Ok (3≤ 3.4)**

For #30 size 27% – 23% = 4% **Fail (4> 2.9)**

The DOT Performed the verification testing on the Corresponding Sample and Obtained the Following Results:

Sieve Size	% Passing
1"	100
3/4"	94
1/2"	72
3/8"	65
#4	50
#8	39
#30	23
#200	4.8

If any fail, see required steps on page 9-32

Grading (Nominal Max. Size)					
	1"	3/4" ↓	1/2"	3/8"	PMWC
Sieve	Allowable Difference (% Passing)				
1 ¼"	1.5				
1"	2	1.5			
¾" →	3 →	2	1.5		
½"	3.4	3	2	1.5	1.5
3/8"	3.4	3.4	3.4	2	2
No. 4	3.4	3.4	3.4	3.4	3.4
No. 8	3.3	3.3	3.3	3.3	3.3
No. 30	2.9	2.9	2.9	2.9	
No. 200	1.2	1.2	1.2	1.2	1.2

Assuming that **PMP ¾"** w … est Results can be used fo …

Verification Testing (Aggregate Gradation)

Problem #2

A Contractor Obtained the Following Gradation for an Aggregate Sample:

Sieve Size	% Passing
1/2"	100
3/8"	96
#4	52
#8	39
#30	17
#200	4.2

Same as above

The DOT Performed the verification testing on the Corresponding Sample and Obtained the Following Results:

Sieve Size	% Passing
1/2"	100
3/8"	93
#4	56
#8	43
#30	21
#200	6.1

Assuming that PMP 3/8” was used, Determine if the contractor’s Test Results can be used for Calculating the Pay Factor.

Verification Testing (Aggregate Gradation)

Problem #3

A Contractor Obtained the Following Gradation for an Aggregate Sample:

Sieve Size	% Passing
3/4"	100
1/2"	96
3/8"	79
#4	61
#8	48
#30	26
#200	4.5

Same as above

The DOT Performed the verification testing on the Corresponding Sample and Obtained the Following Results

Sieve Size	% Passing
3/4"	100
1/2"	94
3/8"	78
#4	59
#8	46
#30	25
#200	4.2

Assuming that PMP ½" was used, Determine if the contractor's Test Results can be used for Calculating the Pay Factor.

Verification Testing (Density)

The Following Densities Were Obtained from Verification Testing. Determine Which Sets Confirm the Contractor's Results.

Contractor's Density	DOT's Density	Difference	Difference Acceptable	Difference Unacceptable
141.2	141.9	0.7 pcf	✖	
142.3	142.1	0.2 pcf	✖	
142.5	141.3	1.2 pcf	✖	
143.5	141.1	2.4 pcf		✖
141.3	144.5	3.2 pcf		✖
143.1	142.9	0.2 pcf	✖	
144.9	143.7	1.2 pcf	✖	
142.3	142.5	0.2 pcf	✖	

From Section 9-34 – Table 2 (TM529) --- Allowable Density

Difference (*between technicians*) 1.50 pcf

If Diff. ≤ 1.50 pcf, then Acceptable

If Diff. > 1.50 pcf, then Unacceptable