



# **AGGREGATES**

## **Section 8 – Aggregate Gradation Calculations**

Section 8 – 1

# Aggregate Analysis T-166

- The T-166 form has several important parts.
  - ▶ Project Identification
  - ▶ Initial Moisture Content
  - ▶ Atterberg Limits
  - ▶ Gradation Analysis
- The sheet shows the results of the lab testing.
  - ▶ Coarse Aggregate (Gilson) Test
  - ▶ Fine Aggregate and Wash Sieve Tests

WYOMING DEPARTMENT OF TRANSPORTATION T-166  
MATERIALS TESTING LABORATORY  
AGGREGATE ANALYSIS (Rev. 10-15)

PROJECT NO.: WYDOT Aggregate Certification Course TEST NUMBER: 1  
ENGINEER: T. L. SAMPLED BY: M.C.S. TOWN: Laramie COUNTY: WY  
DATE RECEIVED: DATE TESTED: FOR USE AS: (See 10-15)

Sample	COARSE AGG.		FINE AGG.		Weight Retained (lb or kg)	% Retained (1/2 in. or 12.5 mm) or larger
	WT RET.	% RET.	WT RET.	% RET.		
After Wash	22.5	0.0	331.2	0.0		
Pre No. 100 (75 µm)						
Post No. 100 (75 µm) Res.			331.2	0.0		
Total Post No. 100 (75 µm)						

Sieve Size	WT RET.	% RET.	COMBINED AGGREGATE		SPEC. % PASSING
			% PASSING 100 (75 µm)	% PASSING 425 (175 µm)	
1/2 in. (12.5 mm)	0.0	0.0			
No. 10 (2.0 mm)	0.0	0.0			
No. 20 (0.85 mm)	0.0	0.0			
No. 40 (0.425 mm)	0.0	0.0			
No. 60 (0.25 mm)	0.0	0.0			
No. 80 (0.18 mm)	0.0	0.0			
No. 100 (0.15 mm)	0.0	0.0			
No. 150 (0.106 mm)	0.0	0.0			
No. 200 (0.075 mm)	0.0	0.0			
Total Passing	0.0	0.0			

MOISTURE		ATTERBERG LIMITS	
Wt. (lb or kg)	% Moisture	LL (%)	PL (%)

REMARKS:

TESTED BY: \_\_\_\_\_  
CERTIFICATION NO. \_\_\_\_\_

**T-166**  
**Example**  
**1**

WEIGHT (lbs or kg)					Weight Retained (lbs or kg)	% Retained = $\left(\frac{A \text{ or } B}{D}\right) \times 100$
COARSE AGG.			FINE AGG.			
Sample	32.6	= (E)	419.9	= (F)		
After Wash			331.1		RETAINED No. 4 (4.75 mm) = (A)	19.50
Pass No. 200 (75µm)			88.8		PASS No. 4 (4.75 mm) = (B)	40.0
Pass No. 200 (75 µm), Pan			33.1		TOTAL, A + B = (D)	32.50
Total Pass No. 200 (75µm)						
SIEVE SIZE	WT RET	% RET =		WT RET	% RET =	
		$\frac{K \times 100}{E}$			$\frac{P \times 100}{F}$	
		=K	=L		=P	=R
1 1/2" (37.5 mm)						
1" (25mm)	2.10	6.4				
3/4" (19 mm)	4.30					
1/2" (12.5 mm)	3.80					
3/8" (9.5 mm)	5.10	15.6				
No. 4 (4.75 mm)	4.20	12.9				
No. 8 (2.36 mm)			77.2		7.4	
No. 16 (1.18 mm)						
No. 30 (600 µm)			61.8	14.7		
No. 40 (425 µm)			55.6			
No. 50 (300 µm)						
No. 100 (150 µm)			59.4	14.1	5.6	
No. 200 (75 µm)			44.0	10.5	4.2	
Pass No. 200 (75 µm), Pan	13.00	39.9	121.9	29.0	11.6	
TOTAL PASSING			419.9	99.9		
SHAKER LOSS %		0.3 %		0.0 %		
FRACTURED FACES %	One or more		SHAKER LOSS FORMULA			
FLAT & ELONGATED %	1:5 Ratio		$(E \text{ or } F) - \text{TOTAL PASSING} / (E \text{ or } F) \times 100$			
					COMBINED AGGREGATE	
					% PASSING 100 - S (Z)	SPEC % PASSING
					=Z	
					to 0.1 %	
					to 1 %	
					100.0	
					93.6	
					13.2	80.4
					11.7	
					15.6	
						40
					7.4	32.8 33
					5.9	26.9 27
					5.3	21.6 22
					5.6	16.0 16
					4.2	11.8 12
					WET WT (lb or kg)	
					DRY WT (lb or kg)	
					WET - DRY - MOISTURE	

Section 8 – 3

# Aggregate Analysis T-166

WYOMING DEPARTMENT OF TRANSPORTATION T-166  
MATERIALS TESTING LABORATORY (Rev. 10-18)  
AGGREGATE ANALYSIS

TEST NUMBER: \_\_\_\_\_  
PROJECT NAME: \_\_\_\_\_  
ENGINEER: \_\_\_\_\_ TOWN: \_\_\_\_\_  
SAMPLE NO. 3/4" Superpave Mix \_\_\_\_\_  
WT OR GROSS WT: \_\_\_\_\_ COUNTY: \_\_\_\_\_  
QUANTITY: \_\_\_\_\_ FOR USE AS: \_\_\_\_\_  
DATE RECEIVED: \_\_\_\_\_ DATE TESTED: \_\_\_\_\_

- This example tests the gradation against the specification for a 3/4" Superpave Mix.
  - The sieve specification range is written in the right-hand column.
  - After the sieve analysis is completed, the results are compared against the range.
- Note: This is a complete sheet with water content, Atterburg Limits and Gradations all calculated.

WEIGHT (lb or kg)		FINE AGG.		Weight Retained (lb or kg)		% Retained (A/B) x 100
Sample	35.0 ± 0.1	376.2	± 0.1	RETAINED No. 4 (14.75 mm) (A)	18.07	50.8 ± 0.3
Pave No. 200 (75 µm)	18.0			PAVE No. 4 (14.75 mm) (B)	17.53	49.2 ± 0.3
Pave No. 200 (75 µm) Plus	23.2			TOTAL A + B (B)	35.60	
Total Pave No. 200 (75 µm)	42.1					

SIEVE SIZE	WT RET	WT	WT	WT	WT	WT	COMBINED AGGREGATE	
							% PASSING 100-µ (Z)	SPCC % PASSING
1" (25.4 mm)	35.0	376.2	376.2	376.2	376.2	376.2	100	100
3/4" (19.0 mm)	3.25	9.1					9.1	90-100
1/2" (12.5 mm)	5.83	15.9					15.9	90-100
3/8" (9.5 mm)	4.65	12.1					12.1	90-100
No. 4 (4.75 mm)	4.31	12.1					12.1	90-100
No. 10 (2.0 mm)			67.3	17.9	8.8	8.8	40.5	41
No. 20 (0.85 mm)			59.3	15.8	7.8	7.8	32.7	33
No. 40 (0.425 mm)			52.8	14.0	6.9	6.9	28.3	28
No. 60 (0.25 mm)			49.5	13.2	6.5	6.5	19.3	19
No. 100 (0.15 mm)			53.3	14.2	7.0	7.0	12.3	12
No. 200 (0.075 mm)			52.1	13.8	6.8	6.8	5.5	5.5
Pave No. 200 (75 µm) Plus	17.53	49.2	42.1	11.2	9.5			2-7
TOTAL PASSING	35.60	99.9	276.2	100.0				
SEAKER LOSS %								
FLAT & ELONGATED %								
FINENESS MODULUS: see M.T.A.L. Sect. 816.6								
WATER CONTENT (W)								
LIQUID LIMIT (LL)								
PLASTIC LIMIT (PL)								

**T-166**  
**Example 2**

WEIGHT (lbs or kg)					Weight Retained (lbs or kg)	% Retained = $\left(\frac{A \text{ or } B}{D}\right) \times 100$			
COARSE AGG.			FINE AGG.						
Sample	35.6	= (E)	376.2	= (F)					
After Wash			357.3		RETAINED No. 4 (4.75 mm) = (A)	18.07	50.8	= (H)	
Pass No. 200 (75µm)			18.9		PASS No. 4 (4.75 mm)= (B)	17.53	49.2	= (I)	
Pass No. 200 (75 µm), Pan			23.2		TOTAL, A + B = (D)	35.60		= (J)	
Total Pass No. 200 (75µm)									
SIEVE SIZE	WT RET	% RET = $\frac{K \times 100}{E}$	WT RET	% RET = $\frac{P \times 100}{F}$	% RET = $\frac{R \times 1}{100}$	COMBINED AGGREGATE			
		% PASSING 100 - S ( Z )			SPEC % PASSING				
		=Z		to 0.1 %		to 1 %			
1 1/2" (37.5 mm)						100.0	100		
1" (25mm)								100	
3/4" (19 mm)	3.25	9.1			9.1	90.9	91	90-100	
1/2" (12.5 mm)	5.83	16.4			16.4	74.5	75	55-90	
3/8" (9.5 mm)	4.68							45-85	
No. 4 (4.75 mm)	4.31							30-65	
No. 8 (2.36 mm)			67.3	17.9	8.8	8.8		20-50	
No. 16 (1.18 mm)			59.3	15.8	7.8	7.8	32.7		
No. 30 (600 µm)			52.6				25.8	26	5-30
No. 40 (425 µm)			49.5						
No. 50 (300 µm)									
No. 100 (150 µm)			53.3		7.0			12	
No. 200 (75 µm)			52.1			6.8	5.5	5.5	2-7
Pass No. 200 (75 µm), Pan	17.53		42.1		5.5				
TOTAL PASSING		99.9	376.2	100.0					
SHAKER LOSS %		0.0 %		0.0 %					
FRACTURED FACES %	One or more		SHAKER LOSS FORMULA			WET WT (lb or kg)	37.3		
FLAT & ELONGATED %	1:5 Ratio		(G or I) - TOTAL PASSING / (E or F) * 100			DRY WT (lb or kg)	35.6		
						WET - DRY - MOISTURE	1.7		

Section 8 – 5



WYOMING DEPARTMENT OF TRANSPORTATION T-106  
MATERIALS TESTING LABORATORY (Rev. 10-15)  
AGGREGATE ANALYSIS

PROJECT NO.: \_\_\_\_\_  
ENGINEER: \_\_\_\_\_  
SAMPLE ID: 3/4 Superpave Mix  
PT OR QUANTITY: \_\_\_\_\_  
QUANTITY: \_\_\_\_\_  
DATE RECEIVED: \_\_\_\_\_  
DATE TESTED: \_\_\_\_\_

Sample		WEIGHT (lbs or kg)		TEST NUMBER	
CONV. FACT.	FIN. AGG.	FIN. AGG.	FIN. AGG.	PROJECT NAME	TOWN
35.00 = 80	376.2	357.3	18.9	SAMPLED BY:	COUNTY:
Pass No. 200175and		23.2	42.1	FOR USE AS:	
Pass No. 200175and					
Test Pass No. 200175and					
Sieve Size		WT RET =	WT	RET. PASSING	
		E	RET =	No. 4 (4.75 mm) = A)	
		-K	-L	No. 10 (2.0 mm) = B)	
		-P	-Q	TOTAL, A + B = D)	
		-S	-T	TOTAL, A + B + D)	
1 1/2" (37.5 mm)				CONCRETE AGGREGATE	
1 1/4" (31.5 mm)				No. 20 (0.85 mm) = E)	
3/4" (19 mm)				No. 40 (0.425 mm) = F)	
1/2" (12.5 mm)				No. 60 (0.25 mm) = G)	
3/8" (9.5 mm)				No. 100 (0.15 mm) = H)	
No. 4 (4.75 mm)	4.31	12.1	6.7.3	No. 200 (0.075 mm) = I)	
No. 10 (2.0 mm)			17.9	Pass No. 200175and	
No. 20 (0.85 mm)			18.8	TOTAL PASSING	
No. 40 (0.25 mm)			16.0	SHAKEN LOSS %	
No. 60 (0.25 mm)			13.2	SHAKEN LOSS FORMULA	
No. 100 (0.15 mm)			6.5	No. 200 (0.075 mm) = J)	
No. 200 (0.075 mm)			5.3	No. 400 (0.075 mm) = K)	
Pass No. 200175and	17.55	49.2	42.1	No. 800 (0.075 mm) = L)	
TOTAL PASSING	35.60	99.9	376.2	No. 1600 (0.075 mm) = M)	
SHAKEN LOSS %				No. 3250 (0.075 mm) = N)	
TRACTED LOSS %				No. 6500 (0.075 mm) = O)	
TRACTED LOSS FORMULA				No. 12500 (0.075 mm) = P)	
TRACTED LOSS FORMULA				No. 25000 (0.075 mm) = Q)	
TRACTED LOSS FORMULA				No. 50000 (0.075 mm) = R)	
TRACTED LOSS FORMULA				No. 100000 (0.075 mm) = S)	
TRACTED LOSS FORMULA				No. 200000 (0.075 mm) = T)	
TRACTED LOSS FORMULA				No. 400000 (0.075 mm) = U)	
TRACTED LOSS FORMULA				No. 800000 (0.075 mm) = V)	
TRACTED LOSS FORMULA				No. 1600000 (0.075 mm) = W)	
TRACTED LOSS FORMULA				No. 3200000 (0.075 mm) = X)	
TRACTED LOSS FORMULA				No. 6400000 (0.075 mm) = Y)	
TRACTED LOSS FORMULA				No. 12800000 (0.075 mm) = Z)	
TRACTED LOSS FORMULA				No. 25600000 (0.075 mm) = AA)	
TRACTED LOSS FORMULA				No. 51200000 (0.075 mm) = AB)	
TRACTED LOSS FORMULA				No. 102400000 (0.075 mm) = AC)	
TRACTED LOSS FORMULA				No. 204800000 (0.075 mm) = AD)	
TRACTED LOSS FORMULA				No. 409600000 (0.075 mm) = AE)	
TRACTED LOSS FORMULA				No. 819200000 (0.075 mm) = AF)	
TRACTED LOSS FORMULA				No. 1638400000 (0.075 mm) = AG)	
TRACTED LOSS FORMULA				No. 3276800000 (0.075 mm) = AH)	
TRACTED LOSS FORMULA				No. 6553600000 (0.075 mm) = AI)	
TRACTED LOSS FORMULA				No. 13107200000 (0.075 mm) = AJ)	
TRACTED LOSS FORMULA				No. 26214400000 (0.075 mm) = AK)	
TRACTED LOSS FORMULA				No. 52428800000 (0.075 mm) = AL)	
TRACTED LOSS FORMULA				No. 104857600000 (0.075 mm) = AM)	
TRACTED LOSS FORMULA				No. 209715200000 (0.075 mm) = AN)	
TRACTED LOSS FORMULA				No. 419430400000 (0.075 mm) = AO)	
TRACTED LOSS FORMULA				No. 838860800000 (0.075 mm) = AP)	
TRACTED LOSS FORMULA				No. 1677721600000 (0.075 mm) = AQ)	
TRACTED LOSS FORMULA				No. 3355443200000 (0.075 mm) = AR)	
TRACTED LOSS FORMULA				No. 6710886400000 (0.075 mm) = AS)	
TRACTED LOSS FORMULA				No. 13421772800000 (0.075 mm) = AT)	
TRACTED LOSS FORMULA				No. 26843545600000 (0.075 mm) = AU)	
TRACTED LOSS FORMULA				No. 53687091200000 (0.075 mm) = AV)	
TRACTED LOSS FORMULA				No. 107374182400000 (0.075 mm) = AW)	
TRACTED LOSS FORMULA				No. 214748364800000 (0.075 mm) = AX)	
TRACTED LOSS FORMULA				No. 429496729600000 (0.075 mm) = AY)	
TRACTED LOSS FORMULA				No. 858993459200000 (0.075 mm) = AZ)	
TRACTED LOSS FORMULA				No. 1717986918400000 (0.075 mm) = BA)	
TRACTED LOSS FORMULA				No. 3435973836800000 (0.075 mm) = BB)	
TRACTED LOSS FORMULA				No. 6871947673600000 (0.075 mm) = BC)	
TRACTED LOSS FORMULA				No. 13743895347200000 (0.075 mm) = BD)	
TRACTED LOSS FORMULA				No. 27487790694400000 (0.075 mm) = BE)	
TRACTED LOSS FORMULA				No. 54975581388800000 (0.075 mm) = BF)	
TRACTED LOSS FORMULA				No. 109951162777600000 (0.075 mm) = BG)	
TRACTED LOSS FORMULA				No. 219902325555200000 (0.075 mm) = BH)	
TRACTED LOSS FORMULA				No. 439804651110400000 (0.075 mm) = BI)	
TRACTED LOSS FORMULA				No. 879609302220800000 (0.075 mm) = BJ)	
TRACTED LOSS FORMULA				No. 1759218604441600000 (0.075 mm) = BK)	
TRACTED LOSS FORMULA				No. 3518437208883200000 (0.075 mm) = BL)	
TRACTED LOSS FORMULA				No. 7036874417766400000 (0.075 mm) = BM)	
TRACTED LOSS FORMULA				No. 14073748835532800000 (0.075 mm) = BN)	
TRACTED LOSS FORMULA				No. 28147497671065600000 (0.075 mm) = BO)	
TRACTED LOSS FORMULA				No. 56294995342131200000 (0.075 mm) = BP)	
TRACTED LOSS FORMULA				No. 112589990684262400000 (0.075 mm) = BQ)	
TRACTED LOSS FORMULA				No. 225179981368524800000 (0.075 mm) = BR)	
TRACTED LOSS FORMULA				No. 450359962737049600000 (0.075 mm) = BS)	
TRACTED LOSS FORMULA				No. 900719925474099200000 (0.075 mm) = BT)	
TRACTED LOSS FORMULA				No. 1801439850948198400000 (0.075 mm) = BU)	
TRACTED LOSS FORMULA				No. 3602879701896396800000 (0.075 mm) = BV)	
TRACTED LOSS FORMULA				No. 7205759403792793600000 (0.075 mm) = BW)	
TRACTED LOSS FORMULA				No. 14411518807585587200000 (0.075 mm) = BX)	
TRACTED LOSS FORMULA				No. 28823037615171174400000 (0.075 mm) = BY)	
TRACTED LOSS FORMULA				No. 57646075230342348800000 (0.075 mm) = BZ)	
TRACTED LOSS FORMULA				No. 115292150460684697600000 (0.075 mm) = CA)	
TRACTED LOSS FORMULA				No. 230584300921369395200000 (0.075 mm) = CB)	
TRACTED LOSS FORMULA				No. 461168601842738790400000 (0.075 mm) = CC)	
TRACTED LOSS FORMULA				No. 922337203685477580800000 (0.075 mm) = CD)	
TRACTED LOSS FORMULA				No. 1844674407370955161600000 (0.075 mm) = CE)	
TRACTED LOSS FORMULA				No. 3689348814741910323200000 (0.075 mm) = CF)	
TRACTED LOSS FORMULA				No. 7378697629483820646400000 (0.075 mm) = CG)	
TRACTED LOSS FORMULA				No. 14757395258967641292800000 (0.075 mm) = CH)	
TRACTED LOSS FORMULA				No. 29514790517935282585600000 (0.075 mm) = CI)	
TRACTED LOSS FORMULA				No. 59029581035870565171200000 (0.075 mm) = CJ)	
TRACTED LOSS FORMULA				No. 118059162071741130342400000 (0.075 mm) = CK)	
TRACTED LOSS FORMULA				No. 236118324143482260684800000 (0.075 mm) = CL)	
TRACTED LOSS FORMULA				No. 472236648286964521369600000 (0.075 mm) = CM)	
TRACTED LOSS FORMULA				No. 944473296573929042739200000 (0.075 mm) = CN)	
TRACTED LOSS FORMULA				No. 1888946593147858085478400000 (0.075 mm) = CO)	
TRACTED LOSS FORMULA				No. 3777893186295716170956800000 (0.075 mm) = CP)	
TRACTED LOSS FORMULA				No. 7555786372591432341913600000 (0.075 mm) = CQ)	
TRACTED LOSS FORMULA				No. 15111572745182864683827200000 (0.075 mm) = CR)	
TRACTED LOSS FORMULA				No. 30223145490365729367654400000 (0.075 mm) = CS)	
TRACTED LOSS FORMULA				No. 60446290980731458735308800000 (0.075 mm) = CT)	
TRACTED LOSS FORMULA				No. 120892581961462917470617600000 (0.075 mm) = CU)	
TRACTED LOSS FORMULA				No. 241785163922925834941235200000 (0.075 mm) = CV)	
TRACTED LOSS FORMULA				No. 483570327845851669882470400000 (0.075 mm) = CW)	
TRACTED LOSS FORMULA				No. 967140655691703339764940800000 (0.075 mm) = CX)	
TRACTED LOSS FORMULA				No. 1934281311383406679529881600000 (0.075 mm) = CY)	
TRACTED LOSS FORMULA				No. 3868562622766813359059763200000 (0.075 mm) = CZ)	
TRACTED LOSS FORMULA				No. 7737125245533626718119526400000 (0.075 mm) = DA)	
TRACTED LOSS FORMULA				No. 15474250491067253436239052800000 (0.075 mm) = DB)	
TRACTED LOSS FORMULA				No. 30948500982134506872478105600000 (0.075 mm) = DC)	
TRACTED LOSS FORMULA				No. 61897001964269013744956211200000 (0.075 mm) = DD)	
TRACTED LOSS FORMULA				No. 123794003928538027489912422400000 (0.075 mm) = DE)	
TRACTED LOSS FORMULA				No. 247588007857076054979824844800000 (0.075 mm) = DF)	
TRACTED LOSS FORMULA				No. 495176015714152109959649689600000 (0.075 mm) = DG)	
TRACTED LOSS FORMULA				No. 990352031428304219919399379200000 (0.075 mm) = DH)	
TRACTED LOSS FORMULA				No. 1980704062856608439838798758400000 (0.075 mm) = DI)	
TRACTED LOSS FORMULA				No. 3961408125713216879677597516800000 (0.075 mm) = DJ)	
TRACTED LOSS FORMULA				No. 7922816251426433759355195033600000 (0.075 mm) = DK)	
TRACTED LOSS FORMULA				No. 15845632502852867518710390067200000 (0.075 mm) = DL)	
TRACTED LOSS FORMULA				No. 31691265005705735037420780134400000 (0.075 mm) = DM)	
TRACTED LOSS FORMULA				No. 63382530011411470074841560268800000 (0.075 mm) = DN)	
TRACTED LOSS FORMULA				No. 126765060022822940149683120537600000 (0.075 mm) = DO)	
TRACTED LOSS FORMULA				No. 253530120045645880299366241075200000 (0.075 mm) = DP)	
TRACTED LOSS FORMULA				No. 507060240091291760598732482150400000 (0.075 mm) = DQ)	
TRACTED LOSS FORMULA				No. 1014120480182583521197464964300800000 (0.075 mm) = DR)	
TRACTED LOSS FORMULA				No. 2028240960365167042394929928601600000 (0.075 mm) = DS)	
TRACTED LOSS FORMULA				No. 4056481920730334084789859857203200000 (0.075 mm) = DT)	
TRACTED LOSS FORMULA				No. 8112963841460668169579719714406400000 (0.075 mm) = DU)	
TRACTED LOSS FORMULA				No. 16225927682921336339159439428812800000 (0.075 mm) = DV)	
TRACTED LOSS FORMULA				No. 32451855365842672678318878857625600000 (0.075 mm) = DW)	
TRACTED LOSS FORMULA				No. 64903710731685345356637757715251200000 (0.075 mm) = DX)	
TRACTED LOSS FORMULA				No. 129807421463370690713275515430502400000 (0.075 mm) = DY)	
TRACTED LOSS FORMULA				No. 259614842926741381426551030861004800000 (0.075 mm) = DZ)	
TRACTED LOSS FORMULA				No. 519229685853482762853102061722009600000 (0.075 mm) = EA)	
TRACTED LOSS FORMULA				No. 1038459371706965525706204123444019200000 (0.075 mm) = EB)	
TRACTED LOSS FORMULA				No. 2076918743413931051412408246888038400000 (0.075 mm) = EC)	
TRACTED LOSS FORMULA				No. 4153837486827862102824816493776076800000 (0.075 mm) = ED)	
TRACTED LOSS FORMULA				No. 8307674973655724205649632987552153600000 (0.075 mm) = EE)	
TRACTED LOSS FORMULA				No. 16615349947311448411299365975104287200000 (0.075 mm) = EF)	
TRACTED LOSS FORMULA				No. 3323069989462289682259873195020574400000 (0.075 mm) = EG)	
TRACTED LOSS FORMULA				No. 664613997892457936451974690004148800000 (0.075 mm) = EH)	
TRACTED LOSS FORMULA				No. 1329227995784915872903949380008377600000 (0.075 mm) = EI)	
TRACTED LOSS FORMULA				No. 2658455991569831745807898760016755200000 (0.075 mm) = EJ)	
TRACTED LOSS FORMULA				No. 5316911983139663491615797520033510400000 (0.075 mm) = EK)	
TRACTED LOSS FORMULA				No. 10633823966279326983231595040067020800000 (0.075 mm) = EL)	
TRACTED LOSS FORMULA				No. 21267647932558653966463190080134041600000 (0.075 mm) = EM)	
TRACTED LOSS FORMULA				No. 42535295865117307932926380160268083200000 (0.075 mm) = EN)	
TRACTED LOSS FORMULA				No. 85070591730234615865852760320536166400000 (0.075 mm) = EO)	
TRACTED LOSS FORMULA				No. 170141183460469231731710540641072332800000 (0.075 mm) = EP)	
TRACTED LOSS FORMULA				No. 340282366920938463463421081282144665600000 (0.075 mm) = EQ)	
TRACTED LOSS FORMULA				No. 680564733841876926926842162564289331200000 (0.075 mm) = ER)	
TRACTED LOSS FORMULA				No. 1361129467683753853853684325128578662400000 (0.075 mm) = ES)	
TRACTED LOSS FORMULA				No. 2722258935367507707707368650257157324800000 (0.075 mm) = ET)	
TRACTED LOSS FORMULA				No. 5444517870735015415414737300514346489600000 (0.075 mm) = EU)	
TRACTED LOSS FORMULA				No. 10889035741470030830829474601028692979200000 (0.075 mm) = EV)	
TRACTED LOSS FORMULA				No. 21778071482940061661658949202057385958400000 (0.075 mm) = EW)	
TRACTED LOSS FORMULA				No. 43556142965880123323317898404114771916800000 (0.075 mm) = EX)	
TRACTED LOSS FORMULA				No. 87112285931760246646635796808229543833600000 (0.075 mm) = EY)	
TRACTED LOSS FORMULA				No. 174224571863520493293271593616459087667200000 (0.075 mm) = EZ)	
TRACTED LOSS FORMULA				No. 348449143727040986586543187232918175334400000 (0.075 mm) = FA)	
TRACTED LOSS FORMULA				No. 696898287454081973173086374465836350668800000 (0.075 mm) = FB)	
TRACTED LOSS FORMULA				No. 1393796574908163946346172739311677011337600000 (0.075 mm) = FC)	
TRACTED LOSS FORMULA				No. 2787593149816327892692345478623354022675200000 (0.075 mm) = FD)	
TRACTED LOSS FORMULA				No. 5575186299632655785384690957246708445350400000 (0.075 mm) = FE)	
TRACTED LOSS FORMULA				No. 11150372599265311570769381914493416890700800000 (0.075 mm) =	

## **Correlation of Testing Technicians for Gradation**

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**The actual calculations of the correlation will not be on the exam but you would need to have an appreciation to the process. In addition, you would need to be able to answer general questions about the process.**

Section 8 – 7

## **Correlation of Testing Technicians for Gradation**

**(WYDOT MTM 126.0)**

### **➤ General**

- ▶ **Compares aggregate gradations obtained by WYDOT field laboratory and Contractor's laboratory.**
- ▶ **The paired t-test is used.**
- ▶ **If difference is significant, then the dispute resolution procedure will start.**
- ▶ **Re-correlate if either tester is changed.**
- ▶ **Can be done during aggregate production.**

Section 8 - 8



## **Correlation of Testing Technicians for Gradation**

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### **➤ Procedure**

- ▶ **Obtain 15 aggregate samples**
  - ◆ **Groups of 3**
  - ◆ **Sample according to WYDOT MTM 804**
  - ◆ **5 samples for WYDOT, 5 for contractor, and 5 for referee**
  - ◆ **When sampling from a belt, the middle sample should be the referee sample**
- ▶ **Test samples**
  - ◆ ***WYDOT MTM 814.0***

Section 8 - 9

## **Procedural Steps on Form**

- **Determine percent passing each sieve size**
- **Perform t-test separately for each sieve size**
- **Calculate the difference between % passing**
- **Determine the mean and the Standard Deviation (s) of the differences**

Section 8 - 10

## Procedure (continued)

- Compare  $s$  to the minimum and maximum values in Table 1.

- Calculate 
$$t = \frac{|\bar{x}|}{\sqrt{\frac{s^2}{n}}}$$

- If  $t < 4.604$ ; No significant difference
- If  $t > 4.604$ ; Significant difference
- Check for Sign Error – Do the Differences all have the same sign? May Indicate Bias.

Section 8 - 11

**Table 1. Allowable Range of  
Standard Deviation**

Percent Retained	Grading			
	Coarse		Fine	
	Maximum	Minimum	Maximum	Minimum
< 3%	3.00	0.39	0.60	0.21
3% - 10%	3.00	1.06	1.60	0.57
10% - 20%	4.70	1.66	2.70	0.95
20% - 30%	5.70	2.01	3.50	1.24
30% - 40%	6.90	2.44	4.00	1.41
>40%	9.00	3.18	5.20	1.41

- Use the coarse values unless the nominal maximum aggregate size is #4 or less, in which case use the fine values

Section 8 - 12

## **Directional Bias**

- **Evaluate for directional bias. “Directional bias” exists when all of the paired test differences are positive or negative and the average difference on at least one sieve exceeds the Allowable Gradation Difference in Table 3.**
- **If directional bias exists, consult Subsection 114.3.3, Correlation.**
- **Continue evaluation to find the cause of the directional bias.**

Section 8 - 13

## Table 3 Allowable Gradation Differences

**Table 3. Allowable Gradation Difference**

Sieve	Grading (Nominal Maximum Size)					
	1 inch	¾ inch	½ inch	¾ inch	PMWC	Concrete
	Allowable Difference (% Passing)					
1 ¼ inch	1.5					1.5
1 inch	2.0	1.5				2.0
¾ inch	3.0	2.0	1.5			3.0
½ inch	3.4	3.0	2.0	1.5	1.5	3.4
¾ inch	3.4	3.4	3.4	2.0	2.0	3.4
No. 4	3.4	3.4	3.4	3.4	3.4	3.4
No. 8	3.3	3.3	3.3	3.3	3.3	3.3
No. 16						3.3
No. 30	2.9	2.9	2.9	2.9		
No. 50						2.9
No. 100						2.9
No. 200	1.2	1.2	1.2	1.2	1.2	1.2

Section 8 - 14

## **Resolving Directional Bias**

**Perform additional correlation tests if the correlation procedure shows that directional bias is present. Continue performing correlation testing until the directional bias no longer exists in accordance with Subsection 114.3.4, Resolving Field Test Discrepancies. The department's test results will be used for pay factor analysis while correlation testing is being done. Perform new correlation tests if new equipment or personnel (department or contractor) are introduced during testing.**

Section 8 - 15

### **114.3.4 Resolving Field Testing Discrepancies**

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- 1. Meet with department personnel and review testing procedures, equipment condition, and equipment calibrations in attempt to solve the problem.**
- 2. When cause of the discrepancy has been identified and corrected, repeat the correlation procedure.**
- 3. If the second correlation determines that the contractor's and department's test results represent different sample populations, conduct referee testing.**

Section 8 - 16



### **114.3.4 Resolving Field Testing Discrepancies**

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- 4. The Materials Program will conduct the referee tests using the retained referee samples for aggregate gradations and the department's cores for density testing.**
- 5. The Materials Program will make its results available within five working days of receiving the samples.**
- 6. If the samples represent a quality acceptance lot, the engineer will use test results correlating with the Materials Program test results for the quality acceptance calculations.**

Section 8 - 17

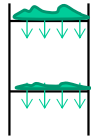
# Correlation of Testing Technicians for Gradation

Example- #1:

Sampler: \_\_\_\_\_  
 Project: \_\_\_\_\_  
 Test Sieve Size: #4  
 Average % Passing 1/2" is 57.2%  
 Grading W - Coarse Gradation

Contractor: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Date: \_\_\_\_\_

#  
#



% Retained =

Sample	Percent Passing Test Sieve		Difference (A) - (B)
	WYDOT (A)	Contractor (B)	
A	49.2	49.8	
B	50.6	46.3	
C	49.6	51.2	
D	51.2	48.3	
E	50.9	48.2	

Average Passing = 49.53



Mean -x: \_\_\_\_\_  
 Std Dev - s: \_\_\_\_\_  
 Min SD: \_\_\_\_\_  
 Max SD: \_\_\_\_\_  
 SD Used: \_\_\_\_\_  
 t : \_\_\_\_\_  
 t > (t<sub>crit</sub>=4.604): \_\_\_\_\_

If  $t > t_{crit}$ , then the data sets are Significantly Different  
 If  $t \leq t_{crit}$ , then the data sets are Not Significantly Different  
 Is there directional bias? \_\_\_\_\_

$$t = \frac{\frac{|x|}{s^2}}{\sqrt{\frac{s^2}{n}}}$$

$$\begin{aligned} s &= 2.513 \\ s \times s &= 2.513 \times 2.513 \\ s^2 &= 6.315 \\ \frac{s^2}{n} &= \frac{6.315}{5} \\ \frac{s^2}{n} &= 1.263 \\ \sqrt{\frac{s^2}{n}} &= \sqrt{1.263} \\ \sqrt{\frac{s^2}{n}} &= 1.124 \\ t &= \frac{\frac{|x|}{s^2}}{\sqrt{\frac{s^2}{n}}} = \frac{1.54}{1.124} \\ t &= 1.371 \end{aligned}$$

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# Correlation of Testing Technicians for Gradation

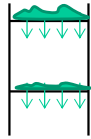
Example - #2:

Sampler: \_\_\_\_\_  
 Project: \_\_\_\_\_  
 Test Sieve Size: #4  
 Average % Passing 1/2" is 57.2%  
 Grading W - Coarse Gradation

Contractor: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Date: \_\_\_\_\_

#

#



% Retained =

Sample	Percent Passing Test Sieve		Difference (A) - (B)
	WYDOT (A)	Contractor (B)	
A	49.2	46.7	
B	50.6	47.3	
C	49.6	47.3	
D	51.2	48.3	
E	50.9	48.2	

Average Passing = 48.93



Mean -x: \_\_\_\_\_  
 Std Dev - s: \_\_\_\_\_  
 Min SD: \_\_\_\_\_  
 Max SD: \_\_\_\_\_  
 SD Used: \_\_\_\_\_  
 t: \_\_\_\_\_  
 t > (t<sub>crit</sub>=4.604): \_\_\_\_\_

If  $t > t_{crit}$ , then the data sets are Significantly Different  
 If  $t \leq t_{crit}$ , then the data sets are Not Significantly Different  
 Is there directional bias? \_\_\_\_\_

$$t = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{n}}}$$

$$s = \frac{s \times s}{x}$$

$$s^2 = \frac{s^2}{n} = \frac{s^2}{5} =$$

$$\frac{s^2}{n} = \frac{s^2}{5} =$$

$$\frac{s^2}{n} = \frac{s^2}{5} =$$

$$\frac{s^2}{n} = \frac{s^2}{5} =$$

$$\sqrt{\frac{s^2}{n}} = \sqrt{\frac{s^2}{5}} =$$

$$\sqrt{\frac{s^2}{n}} = \sqrt{\frac{s^2}{5}} =$$

$$\sqrt{\frac{s^2}{n}} = \sqrt{\frac{s^2}{5}} =$$

$$t = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{n}}} = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{5}}} =$$

$$t = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{n}}} = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{5}}} =$$

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$$t = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{n}}} = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{5}}} =$$

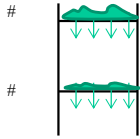
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# Correlation of Testing Technicians for Gradation

Example - #3:

Sampler: \_\_\_\_\_  
 Project: \_\_\_\_\_  
 Test Sieve Size: #200  
 Average % Passing #30 is 14.5%  
 Grading W - Coarse Gradation

Contractor: \_\_\_\_\_  
 Location: \_\_\_\_\_  
 Date: \_\_\_\_\_



% Retained =

Sample	Percent Passing Test Sieve		Difference (A) - (B)
	WYDOT (A)	Contractor (B)	
A	2.75	2.64	
B	2.60	2.81	
C	3.12	3.53	
D	3.05	3.69	
E	2.88	3.01	

Average Passing = 3.01



Mean -x: \_\_\_\_\_  
 Std Dev - s: \_\_\_\_\_  
 Min SD: \_\_\_\_\_  
 Max SD: \_\_\_\_\_  
 SD Used: \_\_\_\_\_  
 t: \_\_\_\_\_  
 t > (t<sub>crit</sub>=4.604): \_\_\_\_\_

$$t = \frac{\frac{\bar{x}}{s^2}}{\sqrt{\frac{s^2}{n}}}$$

If  $t > t_{crit}$ , then the data sets are Significantly Different  
 If  $t \leq t_{crit}$ , then the data sets are Not Significantly Different  
 Is there directional bias? \_\_\_\_\_

Section 8 - 20

# Correlation of Aggregate Gradations

WYOMING DEPARTMENT OF TRANSPORTATION

T 165 AG  
REV (4-2004)

## CORRELATION OF AGGREGATE GRADATIONS

Contractor: \_\_\_\_\_ Consultant: \_\_\_\_\_ Project No(s): \_\_\_\_\_  
 WYDOT: \_\_\_\_\_ Resident Engineer: \_\_\_\_\_ Test is to Correlate (Check One)  
 Testing Date: \_\_\_\_\_ Testers A \_\_\_\_\_  
 QC Supervisor: \_\_\_\_\_ Mechanical Sampler: \_\_\_\_\_ B \_\_\_\_\_

Control Sieve Sizes & Average %	Tester	Percents Passing					Avg	Std Dev	Max SD	Min SD	t crit=	
		Pair A	Pair B	Pair C	Pair D	Pair E					t=	Pass / Fail
	Contractor											
	WYDOT											
	Difference											
	Contractor											
	WYDOT											
	Difference											
	Contractor											
	WYDOT											
	Difference											
	Contractor											
	WYDOT											
	Difference											
	Contractor											
	WYDOT											
	Difference											

Directional Bias on Any Sieve? \_\_\_\_\_ Which One(s)? \_\_\_\_\_

Comments: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Signature of Tester A: \_\_\_\_\_ Signature of Tester B: \_\_\_\_\_ Date: \_\_\_\_\_

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# Correlation of Aggregate Gradations

WYOMING DEPARTMENT OF TRANSPORTATION

T 165 AG  
REV (4-2004)

## CORRELATION OF AGGREGATE GRADATIONS

Contractor: Curly Queue Consultant: Besttesters Project No(s): 12-34-(56)  
WYDOT: Moe Thyme Resident Engineer: Larry Stuge Test is to Correlate (Check One)  
Testing Date: 2/29/99 Testers A X  
QC Supervisor: M. Magoo Mechanical Sampler: \_\_\_\_\_ B \_\_\_\_\_

Control Sieve Size & Average %	Tester	Percents Passing					Avg	Std Dev	Max SD	Min SD	t crit=	
		Pair A	Pair B	Pair C	Pair D	Pair E					t=	Pass / Fail
1"	Contractor	89.9	88.5	92.5	91.1	86.5	89.8					
	WYDOT	91.0	89.6	88.4	92.0	88.9						
	Difference	-1.1	-1.1	4.1	-0.9	-2.4						
3/4"	Contractor	78.6	79.0	77.2	81.2	81.0	79.2					
	WYDOT	79.2	78.9	76.5	79.9	80.5						
	Difference	-0.6	0.1	0.7	1.3	0.5						
1/2"	Contractor	56.3	55.4	55.0	60.4	59.8	58.6					
	WYDOT	58.9	58.0	59.5	60.2	62.3						
	Difference	-2.6	-2.6	-4.5	0.2	-2.5						
#4	Contractor	24.8	24.2	27.2	22.3	24.7	28.2					
	WYDOT	31.3	35.6	31.1	31.6	29.5						
	Difference	-6.5	-11.4	-3.9	-9.3	-4.8						
#30	Contractor	11.5	12.6	10.5	14.0	14.6	13.3					
	WYDOT	14.0	12.9	11.6	15.4	15.9						
	Difference	-2.5	-0.3	-1.1	-1.4	-1.3						
#200	Contractor	6.5	8.2	6.8	7.3	8.9	7.6					
	WYDOT	7.1	8.4	7.3	7.1	7.9						
	Difference	-0.6	-0.2	-0.5	0.2	1.0						

Directional Bias on Any Sieve? Yes \_\_\_\_\_ Which One(s)? #4 \_\_\_\_\_

Comments: There appears to be a significant problem on the #4.

Signature of Tester A: Curly Queue Signature of Tester B: Moe Thyme Date: 2/29/99

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