

APPENDIX D

ANSWERS TO STUDY PROBLEMS

CHAPTER 1

1. **Hydration** is the chemical reaction between water and cement.
2. **Workability** is the property of freshly mixed concrete which is the ease or difficulty in the placing and finishing of concrete.
3. A chemical, such as calcium chloride used to “speed up” the setting time of concrete is **accelerator**.
4. **False set** is a significant loss of plasticity shortly after the concrete is mixed.
5. The time it takes a cement paste to begin hardening is known as **setting time**.
6. A condition at which an aggregate will neither absorb moisture from concrete nor contribute moisture to the mix is **saturated surface dry**.
7. **Set retarder** is a material used for the purpose of delaying the setting time of concrete.
8. **Consistency** is a condition of plastic concrete which relates to its cohesion, wetness, or to flow.
9. **Cement** is the bonding agent used in a concrete mix.
10. The ability of hardened concrete to resist the deterioration caused by weathering, chemicals, and abrasion is known as **durability**.
11. The pH value of water used with cement shall be between **4.5** and **8.5** as found in Section **216.02**.
12. Gypsum is added to cement to control **time of set**.
13. List two desirable qualities of hardened concrete: **durability and water tightness (others listed on page 1-1)**.
14. The primary effect of air entrainment in concrete is to improve **freeze thaw resistance**.
15. List two desirable properties of an aggregate: **low absorption and abrasive resistance (others listed on pages 1-6 to 1-8)**.
16. Admixtures shall be dispensed **according to manufacturer recommendations and within an accuracy of +/-3%**.
17. List two principal raw components in the manufacture of cement: **Lime and Silica**.

18. The type of cement which has the highest fineness reading and the highest tricalcium silicate (C3S) composition, both factors in accelerated strength is **Type III**.
19. The void content of identically graded fine aggregates will vary with **particle shape**.
20. **3.15** is the specific gravity of Portland Cement.
21. **Water-cement ratio** has the greatest effect on the strength, durability and water tightness of concrete.
22. If the amount of admixture is constant and the concrete temperature is increased, the entrained air content will **decrease**.
23. A pH value of 6.0 indicates **acidity** and a pH value of 7.5 indicates **alkalinity**.
24. The strength requirements for High Early Strength Portland Cement Concrete shall be obtained in **7 days** as stated in Section **217.08(b)**.
25. In no case shall a vibrator be operated longer than **15** seconds in any one location as stated in Section **316.04(e)**.
26. The specification requirements for the approval to use admixtures in Hydraulic Cement Concrete are found in Section **215.03**.
27. Each batch of concrete shall be delivered to the site of work and discharged within **90 minutes** of the time the cement is introduced into the mixture unless approved otherwise by the Engineer as found in Section **217.09(b)**.
28. According to Section **217.10**, in cold weather, **water and aggregates** may be heated; however, **cement** is not to be heated.
29. Wash water from hydraulic cement concrete mixer operations is permitted to be reused in the concrete mix according to Section 216.02.

CHAPTER 2

Sieve Analysis - No. 1

Check the following sieve analysis of a sample of natural sand for use in concrete subject to abrasion and determine if it meets Virginia Department of Transportation requirements for Grading "A" Sand. Circle the sieve not passing, if any.

Sieve Size	Cumulative Grams Retained	Cumulative %Retained	%Passing	VDOT Specs. (%Passing)
3/8 inch	0.0	0.0	100.0	100
No. 4	16.6	2.9	97.1	95-100
No. 8	64.5	11.3	88.7	80-100
No. 16	214.1	37.4	62.6	50-85
No. 30	389.2	67.9	32.1	25-60
No. 50	483.0	84.3	15.7	5-30
No. 100	543.4	94.8	5.2	0-10
No. 200	565.0	98.6	1.4	0-3
Total Wt.	<u>573.0</u>			

Yes XX No _____

What is the Fineness Modulus? 2.99

$$\frac{0.0 + 2.9 + 11.3 + 37.4 + 67.9 + 84.3 + 94.8}{100} = \frac{298.6}{100} = 2.99$$

Sieve Analysis - No. 2

Check the following sieve analysis of a sample of natural sand for use in concrete subject to abrasion and determine if it meets Virginia Department of Transportation requirements for Grading "A" Sand. Circle the sieve not passing, if any.

Sieve Size	Cumulative Grams Retained	Cumulative %Retained	%Passing	VDOT Specs. (%Passing)
3/8 inch	0.0	0.0	100.0	100
No. 4	6.9	1.4	98.6	95-100
No. 8	28.3	5.6	94.4	80-100
No. 16	34.9	6.9	93.1	50-85
No. 30	219.2	43.6	56.4	25-60
No. 50	398.8	79.3	20.7	5-30
No. 100	482.9	96.0	4.0	0-10
No. 200	498.1	99.0	1.0	0-3
Total Wt.	<u>503.0</u>			

Yes _____ No XX

What is the Fineness Modulus? 2.33

$$\frac{0.0 + 1.4 + 5.6 + 6.9 + 43.6 + 79.3 + 96.0}{100} = \frac{232.8}{100} = 2.33$$

Sieve Analysis - No. 3

Check the following sieve analysis of a sample of natural sand for use in concrete not subject to abrasion and determine if it meets Virginia Department of Transportation requirements for Grading "A" Sand. Circle the sieve not passing, if any.

Sieve Size	Cumulative Grams Retained	Cumulative %Retained	%Passing	VDOT Specs. (%Passing)
3/8 inch	0.0	0.0	100.0	100
No. 4	6.7	1.4	98.6	95-100
No. 8	54.0	11.3	88.7	80-100
No. 16	168.6	35.1	64.9	50-85
No. 30	340.5	70.9	29.1	25-60
No. 50	407.7	84.9	15.1	5-30
No. 100	459.1	95.6	4.4	0-10
No. 200	468.1	97.5	2.5	0-5
Total Wt.	<u>480.0</u>			

Yes XX No _____

What is the Fineness Modulus? 2.99

$$\frac{0.0 + 1.4 + 11.3 + 35.1 + 70.9 + 84.9 + 95.6}{100} = \frac{299.2}{100} = 2.99$$

ACI MIX DESIGN PROBLEM NO. 2

CLASS A4 General MIX DESIGN

MODIFIED WITH _____

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>3.0</u>	DRY RODDED UNIT WT. <u>105 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>2.83</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.65</u>
OTHER DATA NEEDED FOR SPECIAL DESIGNS	<u>Sp.Gr. of IP 3.02</u>

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.65 X 27 ft³ X UNIT WT. 105 = 1843 lbs.

ABSOLUTE VOLUMES

IP PORTLAND CEMENT	<u>635</u> lbs.	=	<u>3.37</u> ft ³
	<u>3.02 x 62.4</u>		
WATER	<u>.45 x 635 = 286</u> lbs.	=	<u>4.58</u> ft ³
	<u>1.00 x 62.4</u>		
AIR	<u>6.5</u> % x 27	=	<u>1.76</u> ft ³
	<u>100</u>		
C. AGGR.	<u>1843</u> lbs.	=	<u>10.44</u> ft ³
	<u>SP.GR. 2.83</u> X 62.4		
ADDITIONAL MATERIALS	_____	=	_____ ft ³
	_____	=	_____ ft ³
	TOTAL	=	<u>20.15</u> ft ³
	<u>27.00</u> ft ³		
	- <u>20.15</u> ft ³		
F.A.	<u>6.85</u> ft ³ X <u>2.64</u> SP.GR. X 62.4	=	<u>1128</u> lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 635 lbs.

WATER 286 lbs. or 34.3 gals.

AIR 6.5 %

C. AGGR. 1843 lbs. - [_____] + [_____]

F. AGGR. 1128 lbs. - [_____] + [_____]

ADDL. MATLS. _____ =

_____ =

ACI MIX DESIGN PROBLEM NO. 3

CLASS A4 Post & Rail MIX DESIGN

FINE AGGREGATE F.M. <u>2.7</u> SP. GR. <u>2.62</u> MAX. SIZE C.A. <u>½ inch</u> OTHER DATA NEEDED FOR SPECIAL DESIGNS <u>Slag 40% Replacement (Sp. Gr. 2.94)</u> QUANTITY OF COARSE AGGREGATE TABLE A1.5.3.6 <u>0.56</u> X 27 ft ³ X UNIT WT. <u>101</u> = <u>1527</u> lbs.	MODIFIED WITH <u>Slag</u> COARSE AGGREGATE DRY RODDED UNIT WT. <u>101 lb/ft³</u> SP. GR. <u>2.62</u> TABLE A1.5.3.6 FACTOR <u>0.56</u> <u>w/c 0.43</u>
--	--

ABSOLUTE VOLUMES

PORTLAND CEMENT	.40 x 635 = 254	$\frac{635 - 254}{3.15 \times 62.4} = 381$ lbs.	= <u>1.94</u> ft ³
WATER	.43 x 635 = 273	$\frac{273}{1.00 \times 62.4} = 4.38$	= <u>4.38</u> ft ³
AIR	7.0	$\frac{7.0}{100} \times 27 = 1.89$	= <u>1.89</u> ft ³
C. AGGR.	1527	$\frac{1527}{\text{SP.GR. } 2.62} \times 62.4 = 9.34$	= <u>9.34</u> ft ³
ADDITIONAL MATERIALS	40% Slag	$\frac{635 \times .40}{2.94 \times 62.4} = 1.38$	= <u>1.38</u> ft ³
		= _____	= _____ ft ³
		TOTAL	= <u>18.93</u> ft ³
	27.00	ft ³	
	- 18.93	ft ³	
F.A.	<u>8.07</u>	ft ³ X <u>2.62</u> SP.GR. X 62.4	= <u>1319</u> lbs.

SUGGESTED QUANTITIES

± 5% TOLERANCE

CEMENT 381 lbs.

WATER 273 lbs. or 32.8 gals.

AIR 7.0 %

C. AGGR. 1527 lbs. - [_____] + [_____]

F. AGGR. 1319 lbs. - [_____] + [_____]

ADDL. MATLS. Slag = 254 lbs.

_____ =

ACI MIX DESIGN PROBLEM NO. 4 - MODIFIED WITH FLY ASH

CLASS A4 General MIX DESIGN

MODIFIED WITH Fly Ash

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>3.0</u>	DRY RODDED UNIT WT. <u>105 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>3.04</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.65</u>

OTHER DATA NEEDED FOR SPECIAL DESIGNS Fly Ash 20% Replacement
Sp. Gr. 2.35

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.65 X 27 ft³ X UNIT WT. 105 = 1843 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT $.20 \times 635 = 127$ lbs. $\frac{127}{3.15 \times 62.4} = 2.58$ ft³

WATER $.45 \times 635 = 286$ lbs. $\frac{286}{1.00 \times 62.4} = 4.58$ ft³

AIR $\frac{6.5\% \times 27}{100} = 1.76$ ft³

C. AGGR. $\frac{1843 \text{ lbs.}}{3.04 \times 62.4} = 9.72$ ft³

ADDITIONAL MATERIALS $\frac{635 \times .20 = 127}{2.35 \times 62.4} = 0.87$ ft³

	TOTAL	
27.00		= <u>19.51</u> ft ³
- <u>19.51</u>		ft ³

F.A. 7.49 ft³ X 2.64 SP.GR. X 62.4 = 1234 lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 508 lbs.

WATER 286 lbs. or 34.3 gals.

AIR 6.5 %

C. AGGR. 1843 lbs. - [] + []

F. AGGR. 1234 lbs. - [] + []

ADDL. MATLS. Fly Ash = 127 lbs.

_____ =

ACI MIX DESIGN PROBLEM NO. 5

CLASS A4 General MIX DESIGN

MODIFIED WITH _____

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>2.8</u>	DRY RODDED UNIT WT. <u>100 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>3.04</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.67</u>
OTHER DATA NEEDED FOR SPECIAL DESIGNS <u>IS Sp. Gr. 3.05</u>	

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.67 X 27 ft³ X UNIT WT. 100 = 1809 lbs.

ABSOLUTE VOLUMES

IS PORTLAND CEMENT	$\frac{635}{3.05 \times 62.4}$ lbs.	=	<u>3.34</u> ft ³
WATER	$\frac{.45 \times 635}{1.00 \times 62.4} = 286$ lbs.	=	<u>4.58</u> ft ³
AIR	$\frac{6.5}{100} \% \times 27$	=	<u>1.76</u> ft ³
C. AGGR.	$\frac{1809}{SP.GR. 3.04} \times 62.4$ lbs.	=	<u>9.54</u> ft ³
ADDITIONAL MATERIALS	_____	=	_____ ft ³
	_____	=	_____ ft ³
	TOTAL	=	<u>19.22</u> ft ³
	27.00 ft ³		
	- <u>19.22</u> ft ³		
F.A.	<u>7.78</u> ft ³ X <u>2.64</u> SP.GR. X 62.4	=	<u>1282</u> lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT	<u>635</u> lbs.
WATER	<u>286</u> lbs. or <u>34.3</u> gals.
AIR	<u>6.5</u> %
C. AGGR.	<u>1809</u> lbs. - [_____] + [_____]
F. AGGR.	<u>1282</u> lbs. - [_____] + [_____]
ADDL. MATLS.	_____ = _____ =

ACI MIX DESIGN PROBLEM NO. 6

CLASS A3 General MIX DESIGN

MODIFIED WITH Slag

FINE AGGREGATE

COARSE AGGREGATE

F.M. 3.0

DRY RODDED UNIT WT. 99 lb/ft³

SP. GR. 2.64

SP. GR. 2.62

MAX. SIZE C.A. 1 inch

TABLE A1.5.3.6 FACTOR 0.65

OTHER DATA NEEDED FOR SPECIAL DESIGNS 40% Slag Replacement (Sp. Gr. 2.94)

QUANTITY OF COARSE AGGREGATE

TABLE A1.5.3.6 0.65 X 27 ft³ X UNIT WT. 99 = 1737 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT .40 x 588 = 235 $\frac{588 - 235 = 353}{3.15 \times 62.4}$ lbs. = 1.80 ft³

WATER $\frac{.49 \times 588 = 288}{1.00 \times 62.4}$ lbs. = 4.62 ft³

AIR $\frac{6.0}{100} \% \times 27 =$ 1.62 ft³

C. AGGR. $\frac{1737}{\text{SP.GR. } 2.62 \times 62.4}$ lbs. = 10.62 ft³

ADDITIONAL MATERIALS $\frac{.40 \times 588 = 235 \text{ lbs.}}{2.94 \times 62.4} =$ 1.28 ft³

= _____ ft³

TOTAL = 19.94 ft³

27.00 ft³

- 19.94 ft³

F.A. 7.06 ft³ X 2.64 SP.GR. X 62.4 = 1163 lbs.

SUGGESTED QUANTITIES

± 5% TOLERANCE

CEMENT 353 lbs.

WATER 288 lbs. or 34.6 gals.

AIR 6.0 %

C. AGGR. 1737 lbs. - [_____] + [_____]

F. AGGR. 1163 lbs. - [_____] + [_____]

ADDL. MATLS. Slag = 235 lbs.

_____ =

ACI MIX DESIGN PROBLEM NO. 7

CLASS A3 Paving MIX DESIGN

MODIFIED WITH Slag

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>2.7</u>	DRY RODDED UNIT WT. <u>104 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>2.60</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.68</u>
OTHER DATA NEEDED FOR SPECIAL DESIGNS <u>50% Slag Replacement (Sp. Gr. 2.94)</u>	

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.68 X 27 ft³ X UNIT WT. 104 = 1909 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT	.50 x 564 = 282	-	282	=	<u>1.43</u>	ft ³
			3.15 x 62.4			
WATER	<u>.49 x 564 = 276</u>			=	<u>4.42</u>	ft ³
			1.00 x 62.4			
AIR	<u>6.0</u>	% x 27		=	<u>1.62</u>	ft ³
		100				
C. AGGR.	<u>1909</u>	lbs.		=	<u>11.77</u>	ft ³
		SP.GR. <u>2.60</u>	X 62.4			
ADDITIONAL MATERIALS	50% Slag	<u>564 x .50 = 282</u>		=	<u>1.54</u>	ft ³
		2.94 x 62.4		=		ft ³
			TOTAL	=	<u>20.78</u>	ft ³
	<u>27.00</u>	ft ³				
	- <u>20.78</u>	ft ³				
F.A.	<u>6.22</u>	ft ³	X <u>2.64</u>	SP.GR. X 62.4	=	<u>1025</u> lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 282 lbs.

WATER 276 lbs. or 33.1 gals.

AIR 6.0 %

C. AGGR. 1909 lbs. - [] + []

F. AGGR. 1025 lbs. - [] + []

ADDL. MATLS. Slag = 282 lbs.

_____ =

ACI MIX DESIGN PROBLEM NO. 8 - MODIFIED WITH FLY ASH

CLASS A3 General MIX DESIGN

MODIFIED WITH Fly Ash

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>2.8</u>	DRY RODDED UNIT WT. <u>105 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>2.63</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.67</u>

OTHER DATA NEEDED FOR SPECIAL DESIGNS 20% Fly Ash Replacement
Sp. Gr. 2.22

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.67 X 27 ft³ X UNIT WT. 105 = 1899 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT	$588 \times .80 = 470$ lbs.		$= 2.39$ ft ³
	$\frac{470}{3.15 \times 62.4}$		
WATER	$.49 \times 588 = 288$ lbs.		$= 4.62$ ft ³
	$\frac{288}{1.00 \times 62.4}$		
AIR	$\frac{6.0}{100} \% \times 27$		$= 1.62$ ft ³
C. AGGR.	$\frac{1899}{2.63} \text{ lbs.}$		$= 11.57$ ft ³
	$\frac{1899}{2.63 \times 62.4}$		
ADDITIONAL MATERIALS	$\frac{588 \times .20 = 118}{2.22 \times 62.4}$		$= 0.85$ ft ³
			$=$ ft ³
	TOTAL		$= 21.05$ ft ³
	27.00 ft ³		
	$- 21.05$ ft ³		

F.A. 5.95 ft³ X 2.64 SP.GR. X 62.4 = 980 lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 470 lbs.

WATER 288 kg or 34.6 gals.

AIR 6.0 %

C. AGGR. 1899 lbs. - [] + []

F. AGGR. 980 lbs. - [] + []

ADDL. MATLS. Fly Ash = 118 lbs.

_____ =

ACI MIX DESIGN PROBLEM NO. 9 - MODIFIED WITH FLY ASH

CLASS A4 General MIX DESIGN

MODIFIED WITH Fly Ash

FINE AGGREGATE	COARSE AGGREGATE
F.M. <u>3.0</u>	DRY RODDED UNIT WT. <u>98 lb/ft³</u>
SP. GR. <u>2.64</u>	SP. GR. <u>2.62</u>
MAX. SIZE C.A. <u>1 inch</u>	TABLE A1.5.3.6 FACTOR <u>0.65</u>

OTHER DATA NEEDED FOR SPECIAL DESIGNS 25% Fly Ash Replacement
Sp. Gr. 2.30

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.65 X 27 ft³ X UNIT WT. 98 = 1720 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT $.25 \times 635 = 159$ $\frac{635 - 159 = 476}{3.15 \times 62.4}$ lbs. = 2.42 ft³

WATER $\frac{.45 \times 635 = 286}{1.00 \times 62.4}$ lbs. = 4.58 ft³

AIR $\frac{6.5}{100} \% \times 27$ = 1.76 ft³

C. AGGR. $\frac{1720}{\text{SP.GR. } 2.62 \times 62.4}$ lbs. = 10.52 ft³

ADDITIONAL MATERIALS $\frac{635 \times .25 = 159}{2.30 \times 62.4}$ = 1.11 ft³

= _____ ft³

TOTAL = 20.39 ft³

27.00 ft³

- 20.39 ft³

F.A. 6.61 ft³ X 2.64 SP.GR. X 62.4 = 1089 lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 476 lbs.

WATER 286 lbs. or 34.3 gals.

AIR 6.5 %

C. AGGR. 1720 lbs. - [_____] + [_____]

F. AGGR. 1089 lbs. - [_____] + [_____]

ADDL. MATLS. Fly Ash = 159 lbs.

_____ = _____

ACI MIX DESIGN PROBLEM NO. 10 - MODIFIED WITH SLAG

CLASS A4 Post & Rail MIX DESIGN

FINE AGGREGATE	MODIFIED WITH <u>Slag</u>
	COARSE AGGREGATE
F.M. <u>2.80</u>	DRY RODDED UNIT WT. <u>102 lb/ft³</u>
SP. GR. <u>2.83</u>	SP. GR. <u>2.81</u>
MAX. SIZE C.A. <u>½ inch</u>	TABLE A1.5.3.6 FACTOR <u>0.55</u>
OTHER DATA NEEDED FOR SPECIAL DESIGNS <u>Slag 50% Replacement (Sp. Gr. 2.85)</u>	

QUANTITY OF COARSE AGGREGATE
 TABLE A1.5.3.6 0.55 X 27 ft³ X UNIT WT. 102 = 1515 lbs.

ABSOLUTE VOLUMES

PORTLAND CEMENT	$635 \times .50 = 318$	$\frac{635 - 318}{3.15 \times 62.4} = \frac{317}{196.56}$	lbs. =	<u>1.61</u>	ft ³
WATER	$.45 \times 635 = 286$	$\frac{286}{1.00 \times 62.4}$	=	<u>4.58</u>	ft ³
AIR	$\frac{7.0}{100} \times 27$		=	<u>1.89</u>	ft ³
C. AGGR.	$\frac{1515}{\text{SP.GR. } 2.81}$	$\frac{\text{lbs.}}{62.4}$	=	<u>8.64</u>	ft ³
ADDITIONAL MATERIALS	50% Slag	$\frac{635 \times .50 = 318}{2.85 \times 62.4}$	=	<u>1.79</u>	ft ³
			=		ft ³
			TOTAL	=	<u>18.51</u> ft ³
	<u>27.00</u>	ft ³			
	-	<u>18.51</u>	ft ³		

F.A. 8.49 ft³ X 2.83 P.GR. X 62.4 = 1499 lbs.

SUGGESTED QUANTITIES ± 5% TOLERANCE

CEMENT 317 lbs.

WATER 286 lbs. or 34.3 gals.

AIR 7.0 %

C. AGGR. 1515 lbs. - [] + []

F. AGGR. 1499 lbs. - [] + []

ADDL. MATLS. Slag 50% = 318 lbs.

_____ =

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 1

The following Class A4 General Use mix design produced a harsh mix. The contractor wants to reduce the harshness. What are the maximum allowable adjustments under VDOT specifications that could be made to reduce the harshness?

Mix Design - One Cu. Yard
Based on SSD Condition

IP Cement	635 lbs.	Sand - F. M.	2.80
Sand	1150 lbs.	Sand - Sp. Gr.	2.64
No. 57	1954 lbs.	CA - Sp. Gr.	3.04
Water	286 lbs.	CA - Unit Weight	108 lb/ft ³
Air	6.5 %	IP Cement - Sp. Gr.	3.05

ANSWERS

Cement 635 lbs.

Sand 1208 lbs.

No. 57 1888 lbs.

Water 286 lbs.

Air 6.5% lbs.

CALCULATIONS:

SAND: $1150 \times 0.05 = 57.5$

$$1150 + 58 = 1208$$

NO 57: $\frac{58}{2.64 \times 62.4} = \frac{58}{164.736} = 0.35$

$$0.35 \times 3.04 \times 62.4 = 66.0$$

$$1954 - 66 = 1888$$

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 2

The following Class A3 General Use mix design produced a harsh mix. The contractor wants to reduce the harshness. What are the maximum allowable adjustments under VDOT specifications that could be made to reduce the harshness?

Mix Design - One Cu. Yard
Based on SSD Condition

IS Cement	588 lbs.	Sand - F. M.	2.70
Sand	983 lbs.	Sand - Sp. Gr.	2.66
No. 57	1909 lbs.	CA - Sp. Gr.	2.61
Water	288 lbs.	CA - Unit Weight	104 lb/ft ³
Air	6.0 %	IS Cement - Sp. Gr.	3.02

ANSWERS

Cement 588 lbs.
 Sand 1032 lbs.
 No. 57 1860 lbs.
 Water 288 lbs.
 Air 6.0 %

CALCULATIONS:

SAND: $983 \times 0.05 = 49.15$
 $983 + 49 = 1032$

NO 57: $\frac{49}{2.66 \times 62.4} = \frac{49}{165.984} = 0.30$
 $0.30 \times 2.61 \times 62.4 = 49$
 $1909 - 49 = 1860$

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 3

The following Class A4 General Use mix design modified with 40% slag produced a harsh mix. The contractor wants to reduce the harshness. What are the maximum allowable adjustments under VDOT specifications that could be made to reduce the harshness?

Mix Design - One Cu. Yard
Based on SSD Condition

Cement	381 lbs.	Sand - F. M.	2.70
Sand	1285 lbs.	Sand - Sp. Gr.	2.62
No. 57	1799 lbs.	CA - Sp. Gr.	3.04
Water	286 lbs.	CA - Unit Weight	98 lb/ft ³
Air	6.5 %		
Slag	254 lbs.	Slag - Sp. Gr.	2.95

ANSWERS

Cement 381 lbs.

Sand 1349 lbs.

No. 57 1725 lbs.

Water 286 lbs.

Air 6.5 %

Slag 254 lbs.

CALCULATIONS:

SAND: $1285 \times 0.05 = 64.25$

$$1285 + 64 = 1349$$

NO 57: $\frac{64}{2.62 \times 62.4} = \frac{64}{163.488} = 0.39$

$$0.39 \times 3.04 \times 62.4 = 74$$

$$1799 - 74 = 1725$$

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 4

The following Class A3 General Use Mix Design produced a 2 inch slump. The contractor wants a 3 inch slump. What are the maximum allowable adjustments under VDOT specifications that could be made to increase the slump as much as possible?

Mix Design - One Cu. Yard
Based on SSD Condition

IP Cement	588 lbs.	Sand - F. M.	2.80
Sand	1107 lbs.	Sand - Sp. Gr.	2.64
No. 57	1934 lbs.	CA - Sp. Gr.	2.83
Water	288 lbs.	CA - Unit Weight	106.9 lb/ft ³
Air	6.0 %	IP Cement - Sp. Gr.	3.05

ANSWERS

Cement 588 lbs.

Sand 1052 lbs.

No. 57 1992 lbs.

Water 288 lbs.

Air 6.0 %

CALCULATIONS:

SAND: $1107 \times 0.05 = 55.35$

$$1107 - 55 = 1052$$

NO 57: $\frac{55}{2.64 \times 62.4} = \frac{55}{164.736} = 0.33$

$$0.33 \times 2.83 \times 62.4 = 58$$

$$1934 + 58 = 1992$$

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 5

The following Class A3 general use mix design modified with 20% flyash produced a 3 inch slump. The contractor wants a 4 inch slump. What are the maximum allowable adjustments under VDOT specifications that could be made to increase the slump as much as possible?

Mix Design - One Cu. Yard
Based on SSD Condition

Cement	470 lbs.	Sand - F. M.	2.80
Sand	1120 lbs.	Sand - Sp. Gr.	2.83
No. 57	1863 lbs.	CA - Sp. Gr.	2.62
Water	288 lbs.	CA - Unit Weight	103 lb/ft ³
Air	6.0 %		
Flyash	118 lbs.	Flyash - Sp. Gr.	3.00

ANSWERS

Cement 470 lbs.

Sand 1064 lbs.

No. 57 1915 lbs.

Water 288 lbs.

Air 6.0 %

Flyash 118 lbs.

CALCULATIONS:

SAND: $1120 \times 0.05 = 56$

$$1120 - 56 = 1064$$

NO 57: $\frac{56}{2.83 \times 62.4} = \frac{56}{176.592} = 0.32$

$$0.32 \times 2.62 \times 62.4 = 52$$

$$1863 + 52 = 1915$$

ACI MIX DESIGN ADJUSTMENT PROBLEM NO. 6

The following Class A4 general use mix design produced a 2 inch slump. The contractor wants a 3 inch slump. What are the maximum allowable adjustments under VDOT specifications that could be made to increase the slump as much as possible?

Mix Design - One Cu. Yard
Based on SSD Condition

IS Cement	635 lbs.	Sand - F. M.	2.90
Sand	1094 lbs.	Sand - Sp. Gr.	2.62
No. 57	1871 lbs.	CA - Sp. Gr.	2.83
Water	286 lbs.	CA - Unit Weight	105 lb/ft ³
Air	6.5 %	IS Cement - Sp. Gr.	3.02

ANSWERS

Cement 635 lbs.

Sand 1039 lbs.

No. 57 1931 lbs.

Water 286 lbs.

Air 6.5 %

CALCULATIONS:

SAND: $1094 \times 0.05 = 54.7$

$$1094 - 55 = 1039$$

NO 57: $\frac{55}{2.62 \times 62.4} = \frac{55}{163.488} = 0.34$

$$0.34 \times 2.83 \times 62.4 = 60$$

$$1871 + 60 = 1931$$

CHAPTER 4

MOISTURE PROBLEM NO. 1

- A. Given the following information, determine the percent of free moisture in the sand and No. 57.

SAND

Weight of wet sample = 635 grams
Weight of dry sample = 598 grams

NO. 57

Weight of wet sample = 1240 grams
Weight of dry sample = 1220 grams

ABSORPTION

Sand = 0.6%
No. 57 = 0.2%

Free Moisture: Sand 5.6% No. 57 1.4%

CALCULATIONS:

Sand:	$\begin{array}{r} 635 \\ - 598 \\ \hline 37 \end{array}$	$\frac{37}{598} \times 100 = 6.2$	$\begin{array}{r} 6.2 \\ - 0.6 \\ \hline 5.6\% \end{array}$
No. 57	$\begin{array}{r} 1240 \\ - 1220 \\ \hline 20 \end{array}$	$\frac{20}{1220} \times 100 = 1.6$	$\begin{array}{r} 1.6 \\ - 0.2 \\ \hline 1.4\% \end{array}$

- B. Based on the preceding moisture determination, correct the following mix design weights to batch weights or "pull weights" for one cubic yard.

Mix Design - One Cubic Yard
Based on SSD Condition

Batch Quantities

Cement	635 lbs.	Cement	<u>635</u> lbs.
Sand	1067 lbs.	Sand	<u>1127</u> lbs.
No. 57	1835 lbs.	No. 57	<u>1861</u> lbs.
Water	288 lbs.	Water	<u>202</u> lbs.
			<u>24.2</u> gals.
Air	6.5 %	Air	<u>6.5</u> %

CALCULATIONS:

Sand: $1067 \times 0.056 = 60$
 $1067 + 60 = 1127$

No. 57: $1835 \times 0.014 = 26$
 $1835 + 26 = 1861$

Water: $60 + 26 = 86$
 $288 - 86 = 202$
 $\frac{202}{8.33} = 24.2$ gals.

MOISTURE PROBLEM NO. 2

- A. Given the following information, determine the percent of free moisture in the sand and No. 57.

SAND

Weight of wet sample = 628 grams
Weight of dry sample = 582 grams

NO. 57

Weight of wet sample = 1245 grams
Weight of dry sample = 1215 grams

ABSORPTION

Sand = 0.9%
No. 57 = 0.4%

Free Moisture: Sand 7.0% No. 57 2.1%

CALCULATIONS:

$$\begin{array}{r} \text{Sand: } 628 \\ - 582 \\ \hline 46 \end{array} \quad \frac{46}{582} \times 100 = 7.9 \quad \begin{array}{r} 7.9 \\ - 0.9 \\ \hline 7.0 \end{array}$$

$$\begin{array}{r} \text{No. 57: } 1245 \\ - 1215 \\ \hline 30 \end{array} \quad \frac{30}{1215} \times 100 = 2.5 \quad \begin{array}{r} 2.5 \\ - 0.4 \\ \hline 2.1 \end{array}$$

- B. Based on the preceding moisture determination, correct the following mix design weights to batch weights or "pull weights" for one cubic yard.

Mix Design - One Cubic Yard
Based on SSD Condition

Batch Quantities

Cement	635 lbs.	Cement	<u>635</u> lbs.
Sand	1070 lbs.	Sand	<u>1145</u> lbs.
No. 57	1840 lbs.	No. 57	<u>1879</u> lbs.
Water	286 lbs.	Water	<u>172</u> lbs.
			<u>20.6</u> gals.
Air	6.0 %	Air	<u>6.0</u> %

CALCULATIONS:

Sand: $1070 \times 0.070 = 75$

$$1070 + 75 = 1145$$

No. 57: $1840 \times 0.021 = 39$

$$1840 + 39 = 1879$$

Water: $75 + 39 = 114$

$$286 - 114 = 172$$

$$\frac{172}{8.33} = 20.6 \text{ gals.}$$

MOISTURE PROBLEM NO. 3

- A. Given the following information, determine the percent of free moisture in the sand and No. 57.

SAND

Weight of wet sample = 621 grams

Weight of dry sample = 580 grams

NO. 57

Weight of wet sample = 1362 grams

Weight of dry sample = 1343 grams

ABSORPTION

Sand = 0.7%

No. 57 = 0.4%

Free Moisture: Sand 6.4 % No. 57 1.0%

CALCULATIONS:

$$\begin{array}{l} \text{Sand:} \quad \begin{array}{r} 621 \\ - 580 \\ \hline 41 \end{array} \quad \begin{array}{r} 41 \\ 580 \end{array} \times 100 = 7.1 \quad \begin{array}{r} 7.1 \\ - 0.7 \\ \hline 6.4 \end{array} \end{array}$$

$$\begin{array}{l} \text{No. 57} \quad \begin{array}{r} 1362 \\ - 1343 \\ \hline 19 \end{array} \quad \begin{array}{r} 19 \\ 1343 \end{array} \times 100 = 1.4 \quad \begin{array}{r} 1.4 \\ - 0.4 \\ \hline 1.0 \end{array} \end{array}$$

- B. Based on the preceding moisture determination, correct the following mix design weights to batch weights or "pull weights" for four cubic yards.

Mix Design - One Cubic Yard
Based on SSD Condition

Batch Quantities

Cement	635 lbs.	Cement	<u>2540</u> lbs.
Sand	1070 lbs.	Sand	<u>4552</u> lbs.
No. 57	1840 lbs.	No. 57	<u>7432</u> lbs.
Water	286 lbs.	Water	<u>800</u> lbs.
			<u>96.0</u> gals.
Air	7.0 %	Air	<u>7.0</u> %

CALCULATIONS:

Sand: $1070 \times 0.064 = 68$
 $(1070 + 68) \times 4 = 4552$

No. 57: $1840 \times 0.010 = 18$
 $(1840 + 18) \times 4 = 7432$

Water: $68 + 18 = 86$
 $(286 - 86) \times 4 = 800$
 $\frac{800}{8.33} = 96.0 \text{ gals.}$

Cement: $635 \times 4 = 2540$

CHAPTER 5

1. Before any concrete is batched, the producer's technician should determine that there is an approved **mix design** at the plant.
2. The required weighing accuracy for cement is **1 percent**.
3. Aggregates arriving at a plant by truck are acceptable for use if they are accompanied by a **statement of certification**.
4. Hopper and cement scales for batching concrete materials must be **serviced by a Private Scale Company**.
5. Aggregates should be handled and stockpiled in such a manner as to minimize **segregation**.
6. The required weighing accuracy for aggregate is **2 percent**.
7. The minimum and maximum limits of volume of concrete which can be mixed in a mixer are **15 percent - 110 percent**.
8. The loader should remain **12 inches** from the ground while removing material if stockpiles are built on the ground.

CHAPTER 6

1. **Producer's Technician** is responsible for designing the Concrete Mix.
2. **Producer's Technician** is responsible for assuring that concrete components are certified or approved.
3. **District Concrete Technician** is responsible for conducting the performance tests, such as yield tests.
4. Making the moisture correction for aggregate is the responsibility of the **Producer's Technician**.
5. Setting all the dials, gauges, scales, and meters at the batch plant is the responsibility of the **Producer's Technician**.

CHAPTER 7

1. What is the first step in a deck repair?
Defining the repair problem
2. What are typical causes of deterioration of concrete?
Corrosion of Reinforcement
Freezing and Thawing Damage
Alkali-Silica Reaction
3. What causes corrosion of reinforcement?
Chlorides
Water
Thin Concrete Cover
4. Why is corrosion of reinforcement a problem?
Causes cracks and delaminations
5. Why is poor drainage a problem?
Water and salt ponds on the surface
Accelerates deterioration of concrete
Promotes frost damage
6. What causes freeze thaw deterioration?
Low air content in concrete
Water expands 9.1% when it freezes
7. Why is alkali silica reaction a problem?
Alkali cement reacts with silica aggregates forming a gel around aggregates
Gel absorbs water and swells
Expanding gel cracks concrete
8. How do you locate deteriorated concrete caused by corrosion of reinforcement?
Chain drag
Half cell potential measurements
Chloride content measurements

9. How do you remove concrete prior to patching?
Mark perimeter
Saw cut perimeter
Pneumatic hammers
10. Patching can be done with what materials?
Ready mixed concrete
Prepackaged patching materials
11. True or False. Patching should include adequate clearance under the reinforcement, saturated surface dry surface, and the use of an internal vibrator.
True
12. When should white, pigmented liquid membrane curing material be applied?
Just before the surface dries
13. How much does typical bridge deck concrete shrink in one to two years?
Approximately 1 inch per 100 feet of length
14. Concrete gains strength the fastest at what temperature?
90°F
15. What information is needed to use the evaporation rate nomograph?
Air temperature
Relative humidity
Concrete temperature
Wind speed
16. What materials do we use to fill cracks?
High molecular weight methacrylate
Epoxy
Urethane
17. Hydraulic cement concrete overlays should be placed on what type surface?
Shot blasted and saturated surface dry

18. What type hydraulic cement concrete overlays are used in Virginia?
Latex-modified
Silica fume
19. Epoxy overlays should be placed on what type surface?
Shot blasted and dry
20. Epoxy test patches are constructed and tested to verify what is acceptable?
Materials
Surface preparation
Batching, mixing and placing materials

CHAPTER 8

1. What are the duties of a Hydraulic Cement Concrete Field Inspector?
To insure that construction operations produce the results called for by the plans and specifications
2. What daily records must the Hydraulic Cement Concrete Field Inspector keep?
Date, location of the work, weather conditions, test results, equipment in use, equipment idle, source of materials, and production records
3. What is a Certified Concrete Field Technician responsible for at the project site?
Quality control of concrete work
4. What is the purpose of inspection?
To keep the Engineer informed as to the progress and the manner in which the work is progressing
5. What are the qualifications of an inspector?
Knowledge, common sense, observational skills and courtesy
6. What is a good relationship of an Inspector with the Contractor?
The inspector should be friendly, but firm and impartial in making decisions
7. Should an inspector know what testing is required at both the concrete plant and on the road?
Yes
8. What safety equipment should be used during road construction?
Hard hats, steel toed shoes, gloves, safety vests, protective clothing, safety glasses or anything else necessary to assure worker safety
9. Between the following pairs of documents, which one has priority?
Special Provision Copied Notes or Plans Special Provision Copied Notes
Plans or Special Provisions Special Provisions
Specifications or Plans Plans

CHAPTER 9

1. When transporting concrete to the job site, how much water can be withheld and added after concrete arrives on the site?

One gallon per cubic yard
2. True. All forms must be mortar tight, sufficiently rigid, and oiled or wetted down before concrete placing.
3. The conditions which are most conducive to causing plastic shrinkage cracks are high winds and low humidity.
4. Exploration of the sub-foundation to determine its adequacy is done by the Contractor.
5. All forms must be treated with approved coating material or water .
6. It is permissible to use reinforcing steel bars with mill scale on them.
7. Proper use of vibrator involves vibrating vertically at regular intervals.
8. Before placing concrete on a surface, the surface should be oiled or wetted.
9. During cold weather concreting, the surface on which the concrete is to be placed should not be less than 40 °F.
10. The Contractor is responsible for removing and replacing concrete injured by frost action or freezing.
11. On a given day, if the air temperature was 60 °F; relative humidity 40%; surface temperature of the plastic concrete 75 °F and the wind velocity is 15 m/h, the Surface Evaporation Rate for Plastic Concrete on concrete bridge deck would be 0.25 lb/ft²/h.
12. Reinforcing steel bars, except those to be placed in vertical mats, shall be tied at every intersection where the spacing is more than 12 inches in any direction as found in Section 406.03(d).
13. When control cylinders are being used to determine removal of formwork from a deck slab, the minimum compressive strength of the deck slab is 60% f'c as found in Section 404.03(j).
14. The requirements for heating water, aggregates and cement in cold weather are water and aggregates 150°F max; cement shall not be heated.
15. In hot weather, all efforts should be made to place the concrete at or below the air temperature.
16. The requirements for the protection of reinforcing steel bars are found in Section 406.03(b).

17. Once concrete has begun to set in the finished surface, it shall not be disturbed or walked upon for a minimum of 24 hours as stated in Section 404.03(1)2.
18. Concrete may be permitted to freely drop a maximum of 1.5 m (5 ft.) as stated in Section 404.03(c).
19. Forms can be removed from a stem footer when the minimum compressive strength of the footer is 30% $f'c$ as found in Section 404.03.
20. In splicing a reinforcing bar, the minimum allowable length of lap is 30 times the bar diameter as found in Section 406.03(e).

Calculations for Concrete Plant Study Problem

1. Cement Weight Calculation (Line A 38-41)
 $635 \text{ lbs. (from TL-27)} \times 8 \text{ cubic yards} = 5,080 \text{ lbs. of cement for 8 cubic yards}$
2. Sand, SSD Weight Calculation (Line A 46-50)
 $946 \text{ lbs. (from TL-27)} \times 8 \text{ cubic yards.} = 7,568 \text{ lbs. of sand for 8 cubic yards}$
3. Sand, Free Water Calculation (Line A 51-53)
 $7,568 \text{ lbs. of sand for 8 cubic yards} \times .06 \text{ (% Free Moisture of Sand Expressed as a decimal)} = 454.1 \text{ lbs. of free water} = 454 \text{ lbs. (rounded to nearest whole lb.)}$
4. Coarse Aggregate (No. 57), SSD Weight Calculation (Line A 60-64)
 $1,922 \text{ lbs. (From TL-27)} \times 8 \text{ cubic yards} = 15,376 \text{ lbs. of Coarse Aggregate for 8 cubic yards}$
5. Coarse Aggregate (No. 57), Free Water Calculation (Line A 65-67)
 $15,376 \text{ lbs. of C.A. (No. 57) for } 8 \text{ yd}^3 \times .002 \text{ (% Free Moist. of C.A. expressed as a decimal)} = 30.8 \text{ lbs. of free water} = 31 \text{ lbs. (Rounded to nearest whole lb.)}$
6. Total Allowable Water (Line B 13-16)
 $32.5 \text{ gals. (From TL-27)} \times 8 \text{ cubic yards} = 260.0 \text{ gals. for 8 cubic yards}$

NOTE: All water on Line A is in pounds, but all water on Line B is in gallons.

7. Water Added at Plant (Line B 20-23)

$454 \text{ lbs. of free water in sand (Line A 51-53)}$
 $+ \underline{31} \text{ lbs. of free water in coarse aggregate (No. 57) (Line A 65-67)}$
 $485 \text{ lbs. of free water in sand and coarse aggregate}$

The pounds of free water in the sand and coarse aggregate from Line A must be converted to gallons. One gallon of water weighs 8.33 lbs.

$\frac{485}{8.33} = 58.2 \text{ gals. of free water in sand and coarse aggregate (rounded to nearest tenth)}$

1 gallon of water per cubic yard is being withheld at the concrete plant on each 8 yd³ load.

$1 \text{ gal. per cubic yard} \times 8 \text{ cubic yards} = 8.0 \text{ gals. of water withheld on each } 8 \text{ yd}^3 \text{ load}$

The 58.2 gals. of free water in the sand and coarse aggregate goes into the mix with this material and becomes part of the mixing water and therefore must be subtracted from the total allowable water. Also, the 8 gals. of water withheld at the plant must be subtracted from the total allowable water.

58.2 gals. of free water in the sand and coarse aggregate
+ 8.0 gals. of water withheld per load at the concrete plant
66.2 gals. of water to be subtracted from the total allowable water

260.0 gals. of total allowable water (Line B 13-16)
- 66.2 gals. of free water in sand and C.A. plus 8 gals. per load withheld at plant
193.8 gals. of water added at plant (Line B 20-23)

8. A. E. Admixture (Line B 31-34)

5.0 oz. (From TL-27) x 8.0 cubic yards = 40.0 oz. for 8 cubic yards

9. Retarding Admixture (Line B 38-41)

25.0 oz. (From TL-27) x 8 cubic yards = 200.0 oz. for 8 cubic yards

Concrete Field Study Problem Solution

Form TL-13

VIRGINIA DEPARTMENT OF TRANSPORTATION MATERIALS DIVISION												
NOTICE OF SHIPMENT OF CONCRETE CYLINDER												
PROJECT NUMBER				PLANT	LOAD NO.	DATE TAKEN			FIRST CYLINDER SAMPLE	SECOND CYLINDER SAMPLE	THIRD CYLINDER SAMPLE	
ROUTE	CO.	SECT.	TYPE			YY	MM	DD				
3458	789	1011	1213	1415	1617	1819	2021	2223	2425	2627	2829	
U000	106	101	C501			411	901	070	062	03		

CLASS OF CONCRETE	A 3 GENERAL
SUBMITTED BY	PROJECT INSPECTORS NAME