YILDIZ TECHNICAL UNIVERSITY
CIVIL ENGINEERING DEPARTMENT BUILDING MATERIALS DIVISION
CONSTRUCTION MATERIALS / PRACTICE 1

QUESTION 1

A sample of moist aggregate with a volume of 200 cm^3 and a mass of 240 g was dried to saturated surface dry (SSD) condition. After drying, the mass and the volume of this sample were 230.8 g and 143 cm^3, respectively.
a) Calculate the moisture content of the aggregate (H%).
b) Calculate bulk density (unit weight) of the moist and the SSD aggregates.
c) Determine the amount of the moist aggregates required both in mass and volume to obtain 1 m^3 of SSD aggregate.
d) Calculate mass of excess water in this amount of the moist aggregate.

a) $Moisture\ Content\ \% = H\% = \frac{W_H - W_0}{W_0} \times 100 = \frac{240 - 230.8}{230.8} \times 100 \cong 4\%$

b) $\beta_H = \frac{W_H}{V_H} = \frac{240}{200} = 1{,}2 g/cm^3 = 1200 kg/m^3$

$\beta_0 = \frac{W_0}{V_0} = \frac{230{,}8}{143} \cong 1{,}6 g/cm^3 = 1600 kg/m^3$

Moisture Condition of Aggregate	Subscript
SSD	o (β_o, W_o)
Moist (H%)	H (β_H, W_H)

c) 1 m^3 moist aggregate → 1200 kg

1 m^3 SSD aggregate →1600 kg

- The amount of the SSD aggregate obtained from 1 m^3 moist aggregate:

  $W_0^{'} = \frac{W_H}{(1+H)} = \frac{1200}{1+0.04} = 1153.85 kg$ → but, required amount of the aggregate: $1m^3$=1600 kg.

- The amount of short (necessary) SSD aggregate:

  $\Delta W_0 = W_0 - W_0^{'} = 1600 - 1153{,}85 = 446{,}15 kg$ (bu miktarda SDYK agr. ihtiyaç var)

- The amount of the moist aggregate to obtain 446,15 kg SSD aggregate:

  $\Delta W_H = \Delta W_0 (1+H) = 446{,}15 \times (1+0{,}04) = 464 kg$

- The total amount of the moist aggregate to obtain 1 m^3 SSD aggregate:

  $\sum W_H = W_H + \Delta W_H = 1200 + 464 = 1664 kg$ (1 m^3 SDYK agrega eldesi için gereken nemli agrega miktarı)

- The amount of required moist aggregate in volume:

  $V_H = \frac{W_H}{\beta_H} = \frac{1664}{1200} = 1{,}39 m^3$ (hacimce gerekli miktar)

d) The amount of free water:

$\Delta_{water} = \Sigma W_H - W_0 = 1664 - 1600 = 64$ kg (fazla/ excessive su miktarı)

QUESTION 2

The sieve analysis was performed on three groups of dry aggregates and the results are given below. According to the test results:

a) Calculate the percentage passing (P%) of each aggregates.
b) Find the appropriate mix ratio of each aggregate considering the limit values of the reference curves.
c) Plot the grading curve of each aggregate and also the mix aggregate (4 curves in total) on the same graph.
d) Calculate the fineness modulus of the mix aggregate.

	AGGREGATE 1: Natural Sand ***1000* g**			AGGREGATE 2: Crushed Stone #1 ***3000* g**			AGGREGATE 3: Crushed Stone #2 ***3000* g**			MIX AGGREGATE		D_{max}=16 mm		
Sieve Size d_i (mm)	Amount Retained (g)	Amount Passed (g)	Passing P_1%	Amount Retained (g)	Amount Passed (g)	Passing P_2%	Amount Retained (g)	Amount Passed (g)	Passing P_3%	Passing P_m%	100-P_m%	A_{16}	B_{16}	C_{16}
31.5	0	***1000***	***100***	0	***3000***	***100***	0	***3000***	***100***	**100**	**0**	100	100	100
22.4	0	***1000***	***100***	0	***3000***	***100***	0	***3000***	***100***	**100**	**0**	98	99	100
16	0	***1000***	***100***	240	***2760***	***92***	220	***2780***	***93***	**95**	**5**	85	92	99
11.2	0	***1000***	***100***	193	***2567***	***86***	1510	***1270***	***42***	**73**	**27**	68	79	90
8	0	***1000***	***100***	796	***1771***	***59***	785	***485***	***16***	**54**	**46**	48	63	77
4	0	***1000***	***100***	982	***789***	***26***	485	***0***	***0***	**38**	**62**	33	49	64
2	236	***764***	***76***	534	***255***	***9***	0	***0***	***0***	**26**	**74**	22	37	52
1	229	***535***	***54***	184	***71***	***2***	0	***0***	***0***	**17**	**83**	15	28	41
0.5	130	***405***	***41***	71	***0***	***0***	0	***0***	***0***	**12**	**88**	10	20	30
0.25	140	***265***	***27***	0	***0***	***0***	0	***0***	***0***	**8**	**92**	6	13	20
0.15	145	***120***	***12***	0	***0***	***0***	0	***0***	***0***	**4**	**96**	3	7	11
Ratio in the mix	**30%**			**30%**			**40%**			**Σ =**	**573**			

SOLUTION

a,b,c) The suitable ratios for these aggregates to form mix aggregate's grading curve in available zone (between A and C curves) are 30%, 30% and 40%, respectively.

$\Sigma a_i\%=100\%$ and $P_{mix,d}=a_1.P_{1,d}+a_2.P_{2,d}+a_3.P_{3,d}+\ldots$

$P_{m,31.5}=100.0.3+100.0.3+100.0.4=100$ → Check: $A_{16,31.5}=100 \leq 100 \leq C_{16,31.5}=100$ ✓

$P_{m,22.4}=100.0.3+100.0.3+100.0.4=100$ → Check: $A_{16,22.4}=98 < 100 \leq C_{16,22.4}=100$ ✓

$P_{m,16}=100.0.3+92.0.3+93.0.4=95$ → Check: $A_{16,16}=85 < 95 < C_{16,16}=99$ ✓

$P_{m,11.2}=100.0.3+86.0.3+42.0.4=73$ → Check: $A_{16,11.2}=68 < 73 < C_{16,11.2}=90$ ✓

$P_{m,8}=100.0.3+59.0.3+16.0.4=54$ → Check: $A_{16,8}=48 < 54 < C_{16,8}=77$ ✓

$P_{m,4}=100.0.3+26.0.3+0.0.4=38$ → Check: $A_{16,4}=33 < 38 < C_{16,4}=64$ ✓

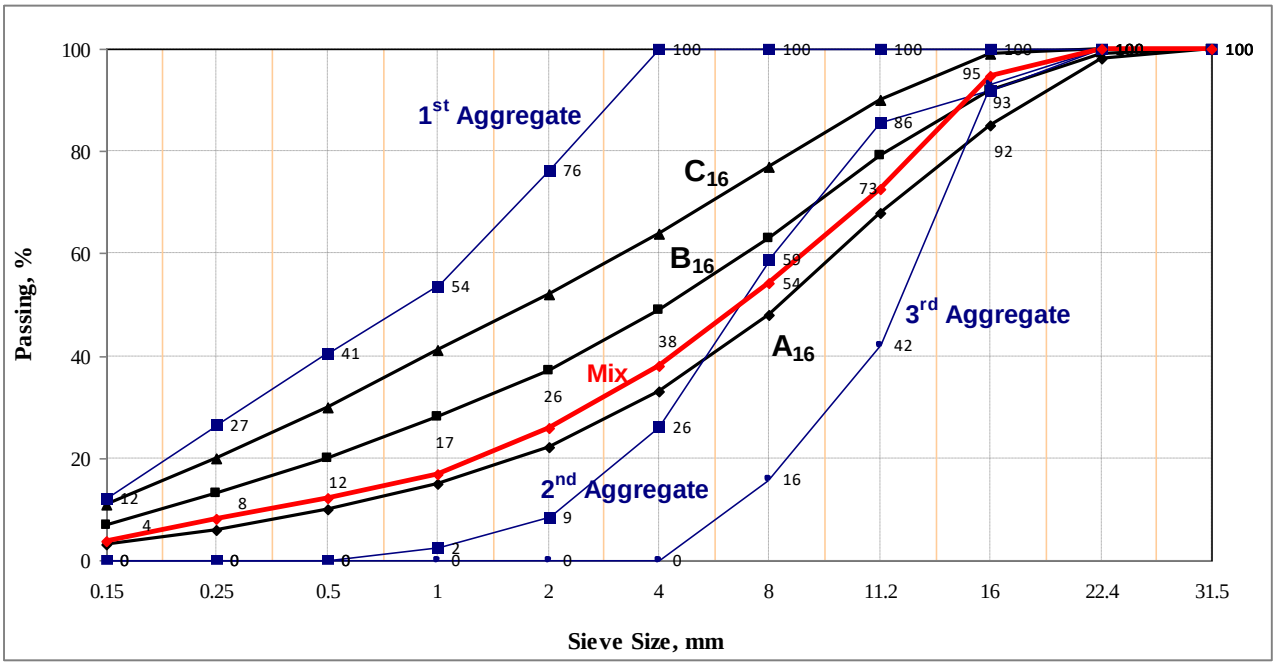
$P_{m,2}=76.0.3+9.0.3+0.0.4=26$ → Check: $A_{16,2}=22 < 26 < C_{16,2}=52$ ✓

$P_{m,1}=54.0.3+2.0.3+0.0.4=17$ → Check: $A_{16,1}=15 < 17 < C_{16,1}=41$ ✓

$P_{m,0.5}=41.0.3+0.0.3+0.0.4=12$ → Check: $A_{16,0.5}=10 < 12 < C_{16,0.5}=30$ ✓

$P_{m,0.25}=27.0.3+0.0.3+0.0.4=8$ → Check: $A_{16,0.25}=6 < 8 < C_{16,0.25}=20$ ✓

$P_{m,0.15}=12.0.3+0.0.3+0.0.4=4$ → Check: $A_{16,0.15}=3 < 4 < C_{16,0.15}=11$ ✓



Note: Other possible acceptable ratio's for a valid grading curve existed between A and C curves:

a_1, a_2, a_3 = 40% / 30% / 30%

a_1, a_2, a_3 = 35% / 35% / 30%

a_1, a_2, a_3 = 35% / 30% / 35%

d) Fineness Modulus: $F_m = \Sigma(100\text{-}P_i\%)/100$

$$F_{m,mix} = \Sigma(100\text{-}P_{mix}\%)/100 = 573/100 = 5.73$$