YILDIZ TECHNICAL UNIVERSITY
CIVIL ENGINEERING DEPARTMENT BUILDING MATERIALS DIVISION
CONSTRUCTION MATERIALS / PRACTICE 2

PROBLEM

A pumping concrete mix for the class of C25/30 with a consistency class S3 (15 cm slump) is required for a reinforced concrete beam construction that may be frequently exposed to freeze /thaw attacks (Exposure Class: XF3) by means of an air-entraining admixture. Concrete cover (C_c) between reinforcement and formwork is 35 mm and minimum dimension of cross-section of the beam is 21 cm.

a) Determine the quantities of constituents for 1 m^3 of concrete mix considering moisture content of the aggregates and with assumption that the air content is 5%. Ratio of superplasticizer and air-entraining admixtures are 1.5% and 0.05%, respectively and solid content is 30% for the superplasticizer. **Assumption:** Usage of 1.5% S.P. reduces 15% of mixing water requirement.

b) 25 dm^3 trial batch was mixed and required 15 cm slump was obtained by adding 300 cm^3 water and the air content was measured as 6%. Determine the adjusted quantities of the constituents considering added water and the measured air content.

c) According to test results of the compression test at the 28th day on 150 mm cubes, the maximum loads at fracture P_1, P_2 and P_3 are 1015 kN, 925 kN and 990 kN, respectively. Check the conformity of this concrete considering the required strength class.

d) This concrete will be cast in construction of a reinforced concrete structural element which has the cross-section given in Figure 2. Calculate average formwork diameter, check the existence of the wall effect and explain precautions must be taken if wall effect exists.

Table 1. Recommended limiting values for composition and properties of concrete (TS EN 206 / January 2017)

XF3	**Minimum Strength Class**	**Maximum Water/Cement**	**Minimum Cement Content (kg/m³)**	**Minimum Air Content (%)**
	C30/37	0.50	320	4.0

Table 2. Physical properties of the constituents

Constituent	**Specific Gravity (γ, kg/dm³)**	**Ratio in the Mix (%)**	**Water Absorption (A_w, %)**	**Moisture Content (M, %)**
Fine aggregate: Natural sand	2.65	47	1.5	3.5
Coarse aggregate 1: Crushed stone No.1	2.80	25	0.8	0.6
Coarse aggregate 2: Crushed stone No.2	2.80	28	0.5	0.5
Cement: CEM I 42,5 R	3.15			
Admixture 1: Superplasticizer	1.15			
Admixture 2: Air-entraining admixture	1.01			

Table 3. Maximum size of aggregate recommended for various types of structural element (TS 802 / March 2016)

Minimum dimension of cross-section of structural element (cm)	Maximum Aggregate Size (mm)			
	Shearwalls, beams and columns	Heavily reinforced slabs	Lightly reinforced and unreinforced slabs	Unreinforced walls
6-14	16	16	32	16
15-29	32	32	63	32
30-74	63	63	63	63

Table 4. Target compressive strengths (f_{cm}) determination (TS 802 / March 2016)

If standard deviation is unknown	$f_{cm} = f_{ck} + \Delta$	$f_{ck} < 20/25$ MPa → Δ =4 MPa $20/25 \leq f_{ck} \leq 30/37$ MPa → Δ =6 MPa $f_{ck} > 30/37$ MPa → Δ =8 MPa

Table 5. Water/Cement ratio for target compressive strength (TS 802 / March 2016)

Compressive strength at 28-day (150x300 mm cylinder) (MPa)	Water / Cement Ratio	
	Non-air entrained concrete	Air entrained concrete
45	0.38	0.30
40	0.42	0.34
35	0.47	0.39
30	0.54	0.45
25	0.61	0.52
20	0.69	0.60
15	0.79	0.70

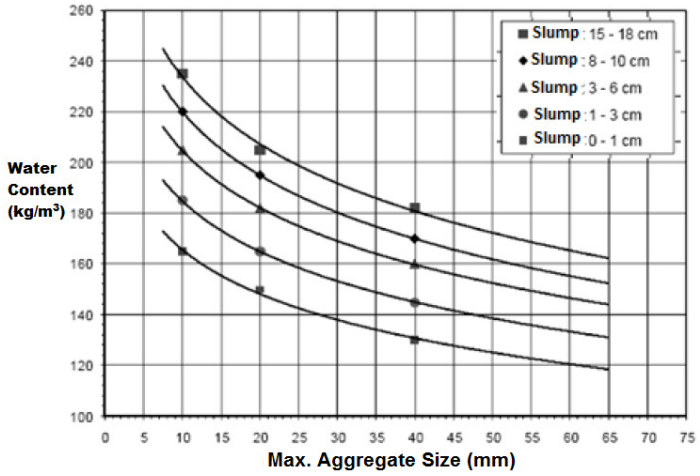

Figure 1. The amount of mixing water of concrete considering maximum aggregate size and required slump value (TS 802 / March 2016)

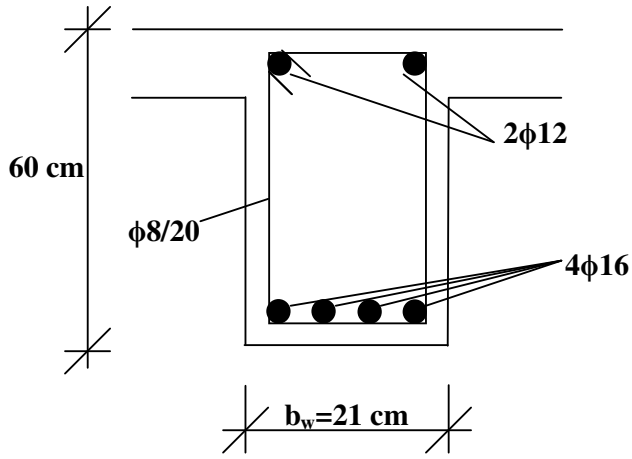

Figure 2. Cross-section of the beam

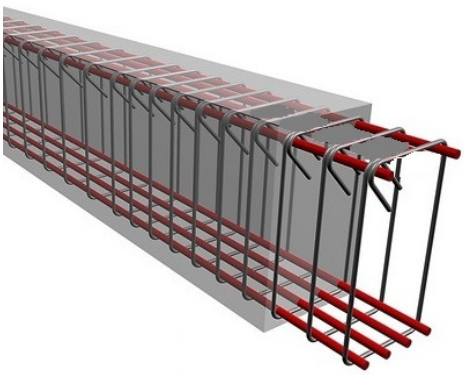

Figure 3. Scheme of the beam