



University Of Technology
Building and Construction Eng. Dept.
Final Exam

2012/2013

Subject :Quality Control

Class: 3rd

Division: Building Eng. & Projects management

Time : 3 Hours

Examiner : MAAN S. HASSAN (PhD)

Date : 20/6/2013

[Answer 4 questions only including No. 2] [اجب عن اربعة اسئلة فقط على ان يكون الثاني من ضمنها]



Q1: According to ISO 9001, what are the quality control requirements for the:

- Process control.
- Purchasing
- Document and data control.
- Control of non-conforming product.
- Design control.

25%

Q2: The following chemical and physical test results have been reported from a construction laboratory for 2 different ordinary Portland cement samples (Type I). Evaluate the results and:

- Calculate the main compounds (C_3S , C_2S , C_3A , C_4AF)?
- Are the results complying with the ASTM specification C150? & Iraqi specification?

Chemical analysis

Oxide	Abbreviation	Cement No. 1	Cement No. 2	ASTM specification C150	Iraqi specification	Notes
SiO ₂ (%)	S	21.1	21.1			
Al ₂ O ₃ (%)	A	5.2	6.2			
Fe ₂ O ₃ (%)	F	3.9	2.9			
CaO (%)	C	65	65			
SO ₃ (%)	S	2.0	2.0			
MgO (%)		1.9	2.0			
Na ₂ O (%)		0.2	0.19			
K ₂ O (%)		0.4	0.4			
Insoluble residual (%)	I.R	0.2	0.2			
Loss on ignition (%)	L.O.I	2.4	2.2			

Physical results

Test	Cement No. 1	Cement No. 2	ASTM specification C150	Iraqi specification	Notes
Fineness (Blaine method) m ² /kg	310	280			
Autoclave expansion (%)	0.19	0.32			
Compressive strength N/mm ²					
3 days	20	17			
7 days	27	23			
28 days	33	30			
Time of setting					
Initial set	1:20 hr	1:30 hr			
Final set	6 hr	8 hr			

25%

Q3: what are the QC requirements on the design and construction stage of formwork?

Q4: The following results are the concrete strength for the previous and current months.

1. Draw Cusum control chart and indicate the change point?
2. Draw Shewhart control chart and calculate the number of results that have exceeded warning level (1/20) and LCL, UCL?

Strength	Previous month (N/mm ²)										Current month (N/mm ²)									
	37	38	35	38	38	40	36	35	38	37	36	35	36	37	35	36	34	35	34	33
Sample No.	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10

25%

Q5 (A): what are the QC requirements for transport of fresh concrete?

15%

Q5 (B): what are the measures that should be adopted for fresh concrete in cold weather?

10%

BOGUE EQUATIONS:

$$\%C_3S = 4.071C - 7.6S - 6.718A - 1.43F - 2.85S$$

$$\%C_2S = 2.867S - 0.7544C_3S$$

$$\%C_3A = 2.650A - 1.692F$$

$$\%C_4AF = 3.043F$$



السمنت البورتلاندي
Portland Cement
(م.ق. ع ٥ لسنة ١٩٨٤)

أولاً: المتطلبات الفيزيائية
بموجب جدول (١)

جدول (١) : المتطلبات الفيزيائية

ت	الفحص	نوع السمنت				
		اعتيادي	معتدل المقاومة للالأملاح	سريع التصلد	واطن الحرارة	مقاوم ابيض
١	النعومة بطريقة بلين لا تقل عن (٢٠كغم) Fineness	٢٣٠	٢٥٠	٣٢٠	٣٢٠	٢٣٠
٢	وقت التماسك * الابتدائي لا يقل عن (دقيقة) * النهائي لا يزيد على (ساعة)	٤٥	٤٥	٤٥	٤٥	٤٥
٣	السلامة: الثبات لا يزيد عن (%) Soundness Autoclave expansion	٠,٨	٠,٨	٠,٨	٠,٨	٠,٨
٤	تحمل الضغط * لا يقل عن ميكانيوتن ^٢ م ^٢ * بعمر يوم واحد * بعمر ثلاثة أيام * بعمر سبعة أيام * بعمر ٢٨ يوم	-	-	١١	-	-
		١٥	١٥	٢١	١٥	١٥
		٢٣	٢٣	٢٨	٢٣	٢٣
		-	-	٢٨	-	-
٥	تحمل الشد (اختياري) (ميكانيوتن ^٢ م ^٢) بعمر يوم واحد	-	-	٢,١	-	-
٦	درجة البياض %	-	-	-	-	٧٨

* يجب أن تكون قوة تحمل الانضغاط عند أي عمر لاحق أعلى من قوة التحمل المستحصلة
عند الفحص بعمر أقل



السمنت البورتلاندي
Portland Cement
(م.ق. ع ٥ لسنة ١٩٨٤)

ثانياً : المتطلبات الكيميائية
بموجب الجدول (٢)

جدول (٢) : المتطلبات الكيميائية

ت	نوع السمنت	اعتيادي	معدل	سريع التصلد	واطن الحرارة	مقاوم	ابيض
١	SiO ₂ لا يقل عن (%)	-	٢١	-	-	-	-
٢	Al ₂ O ₃ لا يقل عن (%)	-	٦	-	-	-	-
٣	Fe ₂ O ₃ لا يقل عن (%)	-	٦	-	٦,٥	-	-
٤	عامل الإشباع الجيري	١,٠٢-٠,٦٦	١,٠٢-٠,٦٦	١,٠٢-٠,٦٦	٠,٨٨-٠,٦٦	١,٠٢-٠,٦٦	١,٠٢-٠,٦٦
٥	MgO لا يزيد على (%)	٥	٥	٥	٥	٥	٥
٦	محتوى SO ₃ لا يزيد على عندما تكون نسبة C ₃ A - اقل من (٥%) - أكثر من (٥%)	٢,٥	٢,٥	٣	٢,٥	٢,٥	٢,٥
٧	الفقدان عند الحرق لا يزيد على %	٤	٤	٤	٤	٤	٤
٨	المواد غير القابلة لذوبان لا تزيد على (%)	١,٥	١,٥	١,٥	١,٥	١,٥	١,٥
٩	C ₃ S لا يزيد على (%)	-	-	-	٣٥	-	-
١٠	C ₂ S لا يزيد على (%)	-	-	-	٤٠	-	-
١١	C ₃ A لا يزيد على (%)	-	٨	١٥	٧	٣,٥	-
١٢	نسبة Fe ₂ O ₃ /Al ₂ O ₃ لا تقل عن	-	-	-	-	-	٨

الرفض : يمكن رفض العبوات التي تختلف وزنها بنسبة تزيد على ٣% من الوزن المؤشر عليها وفي حالة كون معدل وزن (٥٠) عبوة منتقاة بصورة عشوائية من إرسالية أقل من الوزن المؤشر على العبوات فيمكن رفض الإرسالية .

TABLE 1 Standard Composition Requirements

Cement Type ^a	Applicable Test Method	I and IA	II and IIA	III and IIIA	IV	V
Silicon dioxide (SiO ₂), min. %	C 114	...	20.0 ^{b,c}	...	...	...
Aluminum oxide (Al ₂ O ₃), max. %	C 114	...	6.0	...	...	...
Ferric oxide (Fe ₂ O ₃), max. %	C 114	...	6.0 ^d	...	6.5	...
Magnesium oxide (MgO), max. %	C 114	6.0	6.0	6.0	6.0	6.0
Sulfur trioxide (SO ₃), ^e max. %	C 114	...	...	...	...	...
When (C ₃ A) ^f is 8 % or less		3.0	3.0	3.5	2.3	2.3
When (C ₃ A) ^f is more than 8 %		3.5	3.5	4.5	2.5	2.5
Loss on ignition, max. %	C 114	3.0	3.0	3.0	2.5	3.0
Insoluble residue, max. %	C 114	0.75	0.75	0.75	0.75	0.75
Tricalcium silicate (C ₃ S) ^f , max. %	See Annex	...	...	...	35 ^g	...
Dicalcium silicate (C ₂ S) ^f , min. %	See Annex	...	...	...	40 ^g	...
Tricalcium aluminate (C ₃ A) ^f , max. %	See Annex	...	8	15	7 ^g	...
Tetracalcium aluminoferrite plus twice the tricalcium aluminate (C ₄ AF + 2(C ₃ A)), or solid solution (C ₄ AF + C ₂ F), as applicable, max. %	See Annex	...	...	...	...	5 ^c 25 ^c

^a See Note 2.

^b Does not apply when the heat of hydration limit in Table 4 is specified.

^c Does not apply when the sulfate resistance limit in Table 4 is specified.

^d There are cases where optimum SO₃ (using Test Method C 563) for a particular cement is close to or in excess of the limit in this specification. In such cases where properties of a cement can be improved by exceeding the SO₃ limits stated in this table, it is permissible to exceed the values in the table, provided it has been demonstrated by Test Method C 1038 that the cement with the increased SO₃ will not develop expansion in water exceeding 0.020 % at 14 days. When the manufacturer supplies cement under this provision, he shall, upon request, supply supporting data to the purchaser.

^e See Annex for calculation.

^f Not applicable.

TABLE 3 Standard Physical Requirements

Cement Type ^a	Applicable Test Method	I	IA	II	IIA	III	IIIA	IV	V
Air content of mortar, ^b volume %:	C 185								
max.		12	22	12	22	12	22	12	12
min.		...	16	...	16	...	16	...	...
Fineness, ^c specific surface, m ² /kg (alternative methods):									
Turbidimeter test, min.	C 115	150	150	160	160	...	...	150	150
Air permeability test, min.	C 204	280	280	280	260	...	...	280	280
Autoclave expansion, max. %	C 151	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Strength, not less than the values shown for the ages indicated as follows: ^d									
Compressive strength, MPa (psi):	C 109/ C 109M								
1 day		...	...	...	...	12.0 (1740)	10.0 (1450)	...	...
3 days		12.0 (1740)	10.0 (1450)	10.0 (1450)	8.0 (1160)	24.0 (3480)	19.0 (2760)	...	8.0 (1160)
7 days		19.0 (2760)	16.0 (2320)	17.0 (2470)	14.0 (2030)	...	...	7.0 (1020)	15.0 (2180)
28 days		...	...	12.0 ^e (1740) ^e	9.0 ^e (1310) ^e	...	...	...	...
Time of setting (alternative methods): ^d									
Gilmore test:	C 266								
Initial set, min. not less than		60	60	60	60	60	60	60	60
Final set, min. not more than		600	600	600	600	600	600	600	600
Vicat test: ^d	C 191								
Time of setting, min. not less than		45	45	45	45	45	45	45	45
Time of setting, min. not more than		375	375	375	375	375	375	375	375

^a See Note 2.

^b Compliance with the requirements of this specification does not necessarily ensure that the desired air content will be obtained in concrete.

^c The testing laboratory shall select the fineness method to be used. However, when the sample fails to meet the requirements of the air-permeability test, the turbidimeter test shall be used, and the requirements in this table for the turbidimetric method shall govern.

^d The strength at any specified test age shall be not less than that obtained at any previous specified test age.

^e When the optional heat of hydration or the chemical limit on the sum of the tricalcium silicate and tricalcium aluminate is specified.

^f The time-of-setting test required shall be specified by the purchaser. In case he does not so specify, the requirements of the Vicat test only shall govern.

^g The time of setting is that described as initial setting time in Test Method C 191.

Q1

حلولة اسئلة السيطرة لتوكيد
العدد الاول 2013
فرع البناء وادارة المشاريع

3.5 Document and data control

The supplier shall establish and maintain documented procedures to control all documents and data that relate to the requirements of this International Standard including, to the extent applicable, documents of external origin such as standards and customer drawings.

NOTE: Documents and data can be in the form of any type of media, such as hard copy or electronic media.

3.6 Purchasing

The supplier shall establish and maintain documented procedures to ensure that purchased product conforms to specified requirements.

3.7 Process control

The supplier shall identify and plan the production, installation and servicing processes which directly affect quality and shall ensure that these processes are carried out under controlled conditions.

Controlled conditions shall include the following:

- a) Documented procedures defining the manner of production, installation and servicing, where the absence of such procedures could adversely affect quality;

- b) Use of suitable production, installation and servicing equipment, and a suitable working environment;
- c) Compliance with reference standards/codes, quality plans and/or documented procedures;
- d) Monitoring and control of suitable process parameters and product characteristics;
- e) The approval of processes and equipment, as appropriate;
- f) Criteria for workmanship, which shall be stipulated in the clearest practical manner (e.g. written standards, representative samples or illustrations);
- g) Suitable maintenance of equipment to ensure continuing process capability.

3.8 Inspection and testing

The supplier shall establish and maintain documented procedures for inspection and testing activities in order to verify that the specified requirements for the product are met. The required inspection and testing, and the records to be established, shall be detailed in the quality plan or documented procedures.

3.9 Control of nonconforming product

The supplier shall establish and maintain documented procedures to ensure that product that does not conform to specified requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when practical), disposition of nonconforming product, and for notification to the functions concerned.

3.10 Handling, storage, packaging, preservation and delivery

The supplier shall establish and maintain documented procedures for handling, storage, packaging, preservation and delivery of product.

Q2

المشكلة الثانية

$$\begin{aligned} \%C_3S &= 4.071 * 65 - 7.6 * 21.1 - 6.718 * 5.1 \\ &\quad - 1.43 * 3.9 - 2.85 * 2.0 \\ &= 264.615 - 160.36 - 34.933 - 7.117 - 5.7 \\ &= 58.045 \end{aligned}$$

$$\begin{aligned} \%C_2S &= 2.867 * 21.1 = 60.493 - 43.78 \\ &= 16.71 \end{aligned}$$

$$\begin{aligned} \%C_3A &= 2.65 * 5.2 - 1.692 * 3.9 \\ &= 13.78 - 6.5988 \\ &= 7.1812 \end{aligned}$$

$$\%C_4AF = 3.043 * 3.9 = 11.8677$$

for cement No. 2 :-

$$\begin{aligned} C_3S &= 264.615 - 160.36 - 41.65 - 4.147 - 5.7 \\ \%C_3S &= 52.756 \end{aligned}$$

$$\%C_2S = 60.493 - 39.799 = 20.693$$

$$\%C_3A = 16.43 - 4.906 = 11.5232$$

$$\%C_4AF = 5.8247$$

oxide	Comm 1	2	Impai	ClS 0
✓ SO ₃ %	2.0	2.0	≤ 2.8	$\left. \begin{array}{l} \leq 3.0 \text{ (1)} \\ \leq 3.5 \text{ (2)} \end{array} \right\}$
✓ MgO %	1.9	2.0	≤ 5.0%	≤ 6.0%
✓ I.R. %	0.2	0.2	≤ 1.5	≤ 0.75
✓ L.O.I	2.4	2.2	≤ 4.0	≤ 3.0

✓ Fineness m ² /Kg	310	280	≥ 230	≥ 280
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✓ exp. %	0.18	0.32	≤ 0.8%	≤ 0.8%
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✓ Comp. 3 days	20	17	≥ 15	≥ 12
7 days	28	23	≥ 23	≥ 19.0
28 days	33	30	—	—

Time of setting				
initial set	1:20	1:30	≥ 45 min	≥ 45 min
Final set	6	8	≤ 10 hr	≤ 6.25 hr

	(1)	(2)
C ₂₃	58	52-7
C ₂₅	16-73	20-72
C ₂₇	7-18	11-53
C ₂₉	11-65	8-52

56

Q3:

QC requirements for Formwork

BS 5328-3:1990

1- Design and construction

The design and construction of formwork should take account of safety and of the surface finish required. The formwork should be sufficiently rigid and tight to prevent loss of grout or mortar from the fresh concrete. Consideration should be given to the need to nominate a falsework coordinator whose duties would be similar to those outlined in BS 5975.

Formwork and its supports should maintain their correct position and be to correct shape and profile so the final concrete structure is within the limits of the dimensional tolerances specified. They should be designed to withstand the worst combination of self-weight, reinforcement weight, wet concrete weight, concrete pressure, construction and wind loads, together with all incidental dynamic effects caused by placing, vibrating and compacting the concrete. Guidance on these loadings is given in The Concrete Society Manual *Formwork — Guide to good practice*⁹⁾, and in CIRIA Report 108, *Concrete Pressure on Formwork*,¹⁰⁾ and in BS 5975.

Before permanent formwork is used in the structure, its durability and compatibility with adjoining concrete should be established. It should be properly anchored to the concrete.

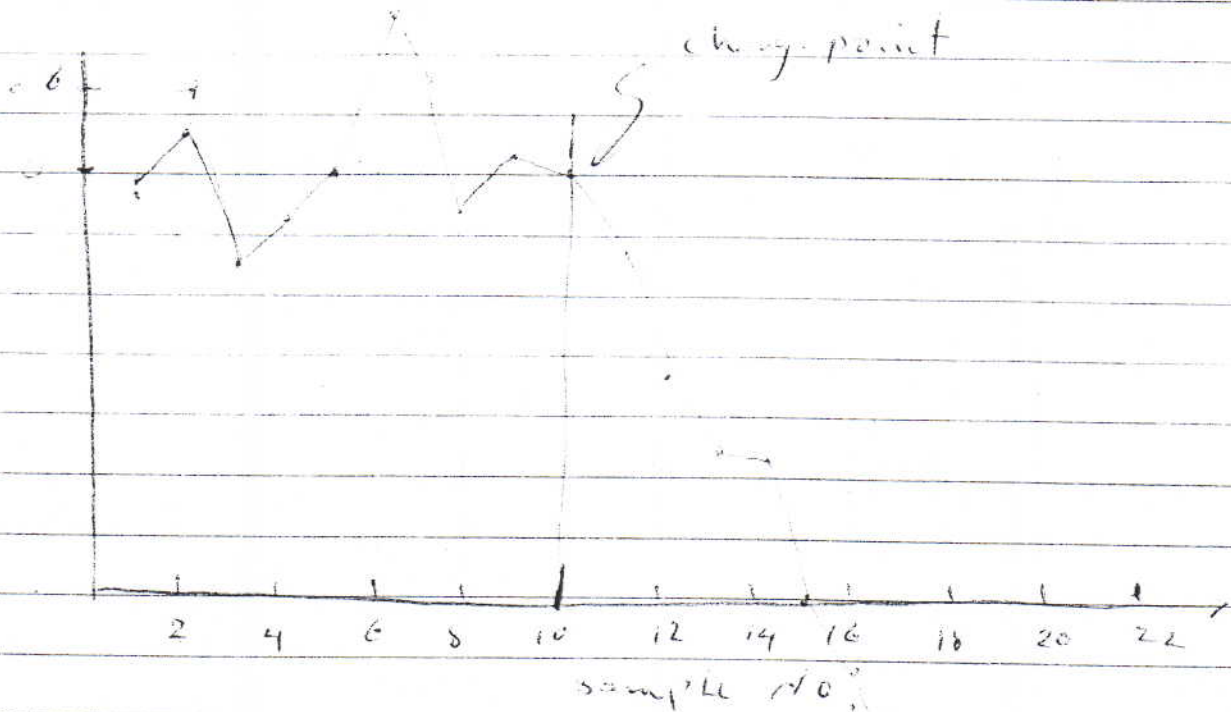
Formwork spacers left in-situ should not impair the desired appearance or durability of the structure, e.g. by causing spalling, rust staining or allowing the passage of moisture. Recommendations for space

Q4:

$$\bar{x} = 37.2$$

$$s^2 = 1.549$$

X_i	$X_i - \bar{X}$	$(X_i - \bar{X})^2$	Cusum	X_i	$X_i - \bar{X}$	Cusum
37	-0.2	.04	-0.2	38	-1.2	-1.2
38	+0.8	.64	+0.8	35	-2.2	-3.4
35	-2.2	4.84	-1.0	36	-1.2	-4.6
38	+0.8	.64	-0.2	34	-2.2	-6.8
35	-2.2	4.84	-1.0	35	-2.2	-9.0
40	+2.8	7.84	+2.8	36	-1.2	-10.2
36	-1.2	1.44	+1.6	37	-0.2	-11.4
35	-2.2	4.84	-0.6	35	-2.2	-13.6
38	+0.8	.64	+0.2	34	-2.2	-15.8
37	-0.2	.04	0	33	-4.2	-20.0
21.6						



$$\bar{x} = 21.6$$

$$s^2 = \frac{1}{n-1} \sum (x_i - \bar{x})^2 = \frac{21.6}{10-1} = 2.4$$

$$s = \sqrt{2.4} = 1.549$$

$$3\sigma = 4.647$$

$$1.65\sigma = 2.558$$

UPU 41.37

37.75

(UCL) 1/1000

(1/20)

UPU 37.2

34.65

32.53

(1/20)

(LCL)

$$\frac{1}{20} \text{ تکرار } \left\{ \begin{array}{l} 3 \\ 3 \\ 3 \\ 3 \\ 1 \\ \hline = 4 \end{array} \right.$$

Q5 (B):

Quality control requirements for concreting in cold weather

In cold weather, consideration should be given to the following:

- a) prevention of freezing of the immature concrete;
- b) extended stiffening times which may lead to increased formwork pressures and delays in finishing;
- c) low rate of concrete strength development which may lead to delays in subsequent construction operation such as striking formwork.

To provide confidence that the concrete can resist permanent damage from freezing the temperature of the concrete should, at no point, fall below 5°C until the concrete in the structural element reaches a strength of 5 N/mm^2 nor should water curing be applied in conditions where freezing of the concrete is anticipated. This should apply regardless of the air temperature at the point of placing. The 5 N/mm^2 strength requirement may be assessed by tests on cubes cured, as far as possible, under the same conditions as the concrete in the element (see 6.1).

Measures which can be adopted for fresh concrete:

- a) increase the specified minimum temperature of the fresh concrete
- b) incorporation of an accelerating admixture.
- c) use of cement that hardens more rapidly;
- d) increase in cement content to raise the heat of hydration