Roll No.													

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd Sem. 2019-20
Course Code: CIV 315
Course Name: ADVANCED CONCRETE TECHNOLOGY
Program & Sem: B.Tech. (CIV) & V

Date: 30.09.2019
Time: 11:00AM to 12.00PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Use of non-programmable Scientific Calculator is permitted
(ii) Read all the questions carefully before answering them

Part A (Memory Recall Questions)

Answer both the Questions. Each Question carries four marks **(2Qx4M=8M)**

1. Write the applications of rapid hardening cement and sulphate resistant cement (C.O.NO.1) [Knowledge]
2. Write the objectives of concrete mix design (C.O NO.1) [Knowledge]

Part B (Thought Provoking Question)

Answer both the Questions. Each Question carries six marks. **(2Qx6M=12M)**

3. Write short notes on i) Plasticizers and ii) Accelerators (C.O.NO.1) [Comprehension]
4. Explain the following admixtures and its effect on properties of concrete
   a) Silica fume b) Fly ash (C.O.NO.2) [Comprehension]

Part C (Problem Solving Questions)

Answer both the Question. Each Question carries ten marks **(2Qx10M=20M)**

5. Design a concrete mix for M35 grade of concrete with the following stipulation as per IS 10262-2009 guidelines: (C.O.NO.1) [Application]

a) Type of exposure : Severe
b) Slump range : 100 -125mm
c) Specific gravity of cement: 3.15
d) Bulk density of cement : 1450 kg/m^3
e) Grading zone of sand : Zone I
f) Specific gravity of sand : 2.62
g) Moisture content of sand : 4 %
h) Water absorption of fine aggregate : 1 %
i) Bulk density : 1700 kg/m^3
j) Maximum size of coarse aggregates : 20mm
k) Specific gravity of coarse aggregates : 2.67
l) Moisture content of coarse aggregates : 1 %
m) Water absorption of coarse aggregate : 0.5 %
n) Bulk density : 1800 kg/m^3
o) Standard deviation : 2 MPa
p) Maximum allowable water cement ratio : 0.45
q) Minimum cement content : 340 kg/m^3
r) Chemical admixture : Super plasticizer with specific gravity of 1.145
s) Dosage of chemical admixture : 2% by volume of cement
t) Method of Placing : Pumping

6. Design a concrete mix using ACI method for construction of an elevated water tank. The specified design strength of concrete (characteristic strength) is 30 MPa at 28 days measured on standard cylinders. Standard deviation can be taken as 4 MPa. The specific gravity of FA and C.A. are 2.65 and 2.7 respectively. The dry rodded bulk density of C.A. is 1600 kg/m3, and fineness modulus of FA is 2.80. Ordinary Portland cement (Type I) will be used. A slump of 50 mm is necessary. C.A. is found to be absorptive to the extent of 1% and free surface moisture in sand is found to be 2 per cent. Assume any other essential data.

(C.O.NO.1) [Application]

PRESIDENCY UNIVERSITY
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SCHOOL OF ENGINEERING

SOLUTION

Even Semester: 2019-20

Course Code: CIV 315

Course Name: Advanced Concrete Technology

Date: 30 Sep 2019

Time: 1 Hour

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	1	Module 1	4									4
2	1	Module 1	4									4
3	1	Module 1				6						6
4	1	Module 1				6						6
5	1	Concrete Mix design				10						10
6	1	Concrete Mix design				10						10
	Total Marks		8			32						40

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

I here certify that All the questions are set as per the above lines Dayalan]

Annexure- II: Format of Answer Scheme

PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

SOLUTION

Even Semester: 2019-20
Course Code: CIV 315
Course Name: Advanced Concrete Technology

Date: 30 Sep 2019
Time: 1 Hour
Max Marks: 40
Weightage: 20%

Part A (2Q x 4M = 8 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	**Uses of Rapid hardening cement:** i)When formwork is to be removed for re-use ii) Where sufficient strength for further construction is wanted as quickly as practicable, such as concrete blocks manufacturing, sidewalks and the places that cannot be closed for a long time, and repair works needed to construct quickly. b) For construction at low temperatures, to prevent the frost damage of the capillary water. **Uses of sulphate resistant cement** a) Concrete to be used in marine condition b) Concrete to be used in foundation and basement, where soil is infested with sulphates c) Concrete to be used in construction of sewage treatment works	**Each application (2x2 =4 M)**	**5 minutes**
2	Mix design should ensure following objectives.: • To achieve the designed/ desired workability in the plastic stage • To achieve the desired minimum strength in the hardened stage • To achieve the desired durability in the given environment conditions • To produce concrete as economically as possible.	**4 points x1 mark**	**5 minutes**

Part B (2Q x 6M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
3	**Plasticizers:** Water reducers reduce the requirement of water for a given workability. In general, these chemicals act as dispersants for portland cement particles. By separating and spreading out the cement particles, internal friction is reduced, and workability of the concrete is increased **Uses of Plasticizers:** Thin walls of water retaining structures with high percentage of steel reinforcement Deep beams, column and beam junctions Hot weather concreting **Accelerators:** Accelerating admixtures are added to concrete to increase the rate of early strength development in concrete to a) permit earlier removal of formwork; b) reduce the required period of curing; c) advance the time that a structure can be placed in service; d) partially compensate for the retarding effect of low temperature during cold weather concreting; e) in the emergency repair work.	Plasticizers : 3M Accelerators 3M	**10 minutes**
4	Flyash: • Reduction of water demand for desired slump. With the reduction of unit water content, bleeding and drying shrinkage will also be reduced. • Contributes to the strength of concrete due to its pozzolanic reactivity. • contributes to making the texture of concrete dense, resulting in decrease of water permeability and gas permeability **Silica fume:** • Too much silica fumes cause the concrete to become sticky and thus reduces the workability • Silica fume addition up to 15% by weight of cement does not result in any loss of workability	Fly ash ; 3M Silica Fume: 3M	**10 minutes**

Part C (1Q x12 M =12 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	As per IS10262: 2009 guidelines: 1. Target Mean Strength 2. Selection of water cement ratio 3. Calculation of water content:	 1 1 1	**15 minutes**

	4. Calculation of cement content: 5.Fine aggregates confirming to zone – I 6.Volume of coarse aggregates with corrections 7. Volume of F.A 8. Volume of cement 9. Volume of water 10.volume of all aggregate 11. weight of C.A and F,A13.Site Corrections for moisture content and water absorption or any other	1 1 1 1 1 1 1	
6	Using ACI method Mean strength (1M) Determination of water cement ratio : 1 M Calculation of cement content : 1M Finding Volume of coarse aggregate : 2M Calculation of Fine aggregate : 2M Calculation of weight of ingredients : 2M Mix proportion : 1M		**15 minutes**

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PRESIDENCY UNIVERSITY
BENGALURU

SCHOOL OF ENGINEERING

TEST - 2

Sem & AY: Odd Sem 2019-20
Course Code: CIV 315
Course Name: ADVANCED CONCRETE TECHNOLOGY
Program & Sem: B.Tech (CIV) & V

Date: 18.11.2019
Time: 11.00 AM to 12.00 PM
Max Marks: 40
Weightage: 20%

Instructions:

(i) Assume any suitable data wherever required

Part A [Memory Recall Questions]

Answer both the Questions. Each Question carries four marks. (2Qx4M=8M)

1. Define the following
   a) Creep
   b) Plastic shrinkage **(CO2, Knowledge)**

2. Define the following **(CO2, Knowledge)**
   a) Efflorescence
   b) Permeability in concrete

Part B [Thought Provoking Questions]

Answer both the Questions. Each Question carries six marks. (2Qx6M=12M)

3. With the help of a neat labeled diagram show the relation of creep with time. **(CO2, Comprehension)**
4. Write short notes on different types of shrinkage occur in various stages of concrete **(CO4, Comprehension)**

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries ten marks. (2Qx10M=20M)

5. Discuss the factors affecting the durability of concrete **(CO4 Application)**
6. Explain the effects of acid attack on concrete and effects of seawater on concrete **(CO2 Comprehension)**

PRESIDENCY UNIVERSITY
BENGALURU
SCHOOL OF ENGINEERING
SOLUTION

Date: 18 Nov 2019

Even Semester: 2019-20

Time: 1 Hour

Course Code: CIV 315

Max Marks: 40

Course Name: Advanced Concrete

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels			Thought provoking type [Marks allotted] Bloom's Levels			Problem Solving type [Marks allotted]			Total Marks
			K			C			A			
1	CO2		4									4
2	CO2		4									4
3	CO2					6						6
4	CO4					6						6
5	CO4								10			10
6	CO2					10						10
	Total Marks		8			22			10			40

K =Knowledge Level C = Comprehension Level, A = Application Level

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme

PRESIDENCY UNIVERSITY
BENGALURU
SCHOOL OF ENGINEERING

SOLUTION

Date: 18 Nov 2019

Even Semester: 2019-20

Time: 1 Hour

Course Code: CIV 315

Max Marks: 40

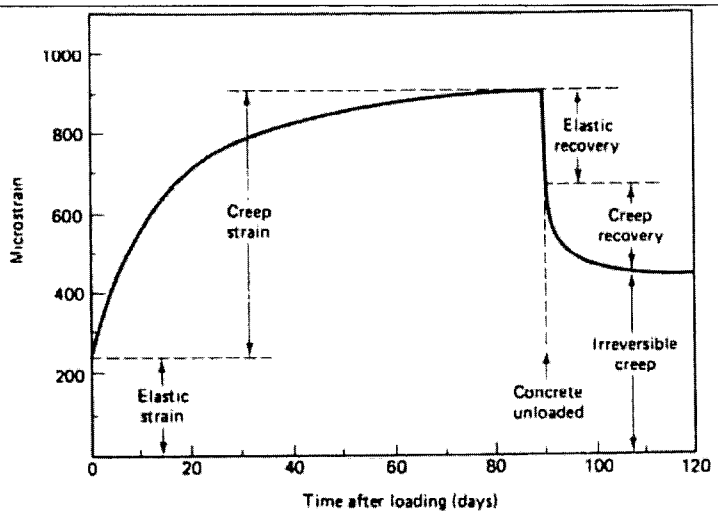
Course Name: Advanced Concrete

Weightage: 20%

Part A (2Q x 4M = 8 Marks)

Q No		Scheme of Marking	Max. Time required for each Question
1	**Concrete creep is defined as**: deformation of structure under sustained load. Basically, long term pressure or stress on concrete can make it change shape. This deformation usually occurs in the direction the force is being applied. **Plastic shrinkage** : Cracking caused by plastic shrinkage in concrete occurs most commonly on the exposed surfaces of freshly placed floors and slabs or other elements with large surface areas when they are subjected to a very rapid loss of moisture caused by low humidity and wind or high temperature or both.	**(2x2 =4 M)**	**5 minutes**
2	**Efflorescence** in concrete is a whitish colored powdered deposition of salts on the concrete surface that is formed due to evaporation of water from the concrete. It is caused when water soluble salts are present in the concrete material, which comes on to the surface while evaporation of water from the concrete. **Permeability** of concrete is defined as the property that controls the rate of flow of fluids into a porous solid. It largely depends on the size of pores, connectivity of pores, and how tortuous the path is for the permeating fluid.	**2 marks**	**5 minutes**

Part B (2Q x 6M = 12Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
3		6M	**10 minutes**
4	**Plastic Shrinkage** -The hydration of cement results in a reduction in the volume of concrete due to evaporation from the surface of concrete, which leads to cracking. **Drying shrinkage** -The shrinkage that appears after the setting and hardening of the concrete mixture due to loss of capillary water is known as drying shrinkage. Drying shrinkage generally occurs in the first few months and decreases with time. **Autogenous shrinkage** - it occurs as a result of the chemical reaction that take place during cement hydration. It is significant in concrete with a very low water- cementitious ratio. **Carbonation shrinkage** occurs due to the reaction of carbon dioxide (CO_2) with the hydrated cement minerals, carbonating $Ca(OH)_2$ to $CaCO_3$. The carbonation slowly penetrates the outer surface of the concrete. This type of shrinkage mainly occurs at medium humidities and results increased strength and reduced permeability.	6 marks	**10 minutes**

Part C (2Q x10 M =20 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	**Factors affecting durability of concrete** **Cement content**	Each category 2 marks	**15 minutes**

	Mix must be designed to ensure cohesion and prevent segregation and bleeding. If cement is reduced, then at fixed w/c ratio the workability will be reduced leading to inadequate compaction. However, if water is added to improve workability, water / cement ratio increases and resulting in highly permeable material. **Compaction** The concrete as a whole contain voids can be caused by inadequate compaction. Usually it is being governed by the compaction equipments used, type of formworks, and density of the steelwork **Curing** It is very important to permit proper strength development aid moisture retention and to ensure hydration process occur completely **Cover** Thickness of concrete cover must follow the limits set in codes **Permeability** It is considered the most important factor for durability. It can be noticed that higher permeability is usually caused by higher porosity. Therefore, a proper curing, sufficient cement, proper compaction and suitable concrete cover could provide a low permeability concrete		
6	**Acid attack**: Concrete is used for the storage of many kinds of liquids, some of which are harmful to concrete. In Industrial plants, concrete floor come in contact with acids, which damage the floor. In damp condition SO_2 and CO_2 and other acid fumes present in the atmosphere affect concrete by dissolving and removing part of the set concrete, This form of attack occurs in chimneys and steam railway tunnels. In fact, no Portland cement is acid resistant. **Sea water** contains sulphates and hence attacks concrete in a manner similar to the sulphate attack. The deterioration of concrete in sea water is often is not characterized by the expansion, as found in concrete exposed to sulphate attack. Attack of sea water causes errosion or loss of constituents of concrete without undue expansion. Calcium	Each category 5 x2 = 10 M	**15 minutes**

	Hydroxide and Calcium Sulphate (gypsum) are considerable soluble in sea water, and this will increase the leaching action. In case of reinforced concrete the absorption of salt results in corrosion of reinforcement. The accumulation of the corrosion product on the steel, causes rupture of the surrounding concrete. So that effect of sea water is more severe on reinforced concrete than on plain concrete.		

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PRESIDENCY UNIVERSITY
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SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester. 2019 - 20 | **Date**: 24 December 2019

Course Code: CIV 315 | **Time**: 9:30 AM to 12:30 PM

Course Name: ADVANCED CONCRETE TECHNOLOGY | **Max Marks**: 80

Program & Sem: B.Tech (CIV) & V (DE-II) | **Weightage**: 40%

Instructions:

(i) Read the all questions carefully and answer accordingly.
(ii) Assume any suitable data wherever required.
(iii) IS 456 and SP 16 charts are permitted.

Part A [Memory Recall Questions]

1. Answer all the Questions. Each Question carries 2 marks. (10Qx2M=20M)

i. With the help of a neat labeled diagram show the relation of creep with time. (C.O.No.2) [Knowledge]

ii. Define Creep and Shrinkage. (C.O.No.2) [Knowledge]

iii. State Different types of shrinkage. (C.O.No.2) [Knowledge]

iv. Draw a stress-strain curve showing various modulus of elasticities. (C.O.No.2) [Knowledge]

v. The increase in strain under sustained stress is defined as _____. (C.O.No.2) [Knowledge]

vi. The ratio of lateral strain to longitudinal strain in a material subjected to loading is _____. (C.O.No.2) [Knowledge]

vii. The reaction of carbon dioxide (CO_2) with the hydrated cement minerals, carbonating $Ca(OH)_2$ to $CaCO_3$ results in _____. (C.O.No.2) [Knowledge]

viii. Give one example each for the following admixtures a) accelerators b) retarders (C.O.No.1) [Knowledge]

ix. Name any 2 types of fibers. Define Aspect Ratio of fibers. (C.O.No.4) [Knowledge]

x. What is the purpose of an L-Box test before placing concrete? (C.O.No.3) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 10 marks. (3Qx10M=30M)

2. What is fiber reinforced concrete? What are the factors that affect the properties of fiber reinforced concrete? How does orientation of fibers play a role in the concrete's strength? (C.O.No.4) [Knowledge]

3. What is self-compacting concrete? What are the properties exhibited by it? What are the disadvantages of using this type of concrete? (C.O.No.4) [Knowledge]

4. Explain the process of vacuum concreting and what are the advantages of this approach? (C.O.No.3) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks. (2Qx15M=30M)

5. Design a concrete mix for M35 grade of concrete with the following stipulation as per IS 10262-2009 guidelines (C.O.No.1) [Application]

Characteristic compressive strength — M 30
Type of Cement — OPC 53 Grade
Maximum Nominal size of aggregate — 20 mm
Shape of CA — Angular
Workability — 100 mm (slump)
Type of exposure — Moderate
Method of placing — Pumpable concrete
Cement Used — OPC 53 Grade Confirming to IS 12269
Chemical admixture — Super plasticizer

Specific Gravity of Cement :		3.15
Specific gravity of Fine Aggregate (sand)	:	2.70
Specific gravity of Coarse Aggregate	:	2.80
Water Absorption of Coarse Aggregate	:	0.4%
Water Absorption of Fine Aggregate	:	1.0%

6. Explain step by step procedure of the calculation of design mix of concrete that is used for the construction of a jetty, based on ACI mix design method. Elaborate by mentioning table numbers and their purpose of reference for design. In addition to that with reference to air entrainment in concrete structures distinguish between mild, moderate and severe conditions. (C.O.No.1) [Comprehension]

SCHOOL OF ENGINEERING

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END TERM FINAL EXAMINATION

Extract of question distribution [outcome wise & level wise]

Q.NO.	C.O.NO (% age of CO)	Unit/Module Number/Unit /Module Title	Memory recall type [Marks allotted] Bloom's Levels	Thought provoking type [Marks allotted] Bloom's Levels	Problem Solving type [Marks allotted]	Total Marks
			K	C	A	
1	C.O.No.1 C.O.No.2 C.O.No.3 C.O.No.4	All four modules	20			20
2	C.O.No.4	Special Concretes	10			10
3	C.O.No.4	Special Concretes	10			10
4	C.O.No.3	Placing, Curing and Maintenance of concrete		10		10
5	C.O.No.1	Basic of concrete and Mix design			15	15
6	C.O.No.1	Basic of concrete and Mix design		15		15
.	Total Marks		40	35	15	80

K =Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt. I hereby certify that all the questions are set as per the above guidelines.

Faculty Signature:

Reviewer Commend:

Format of Answer Scheme

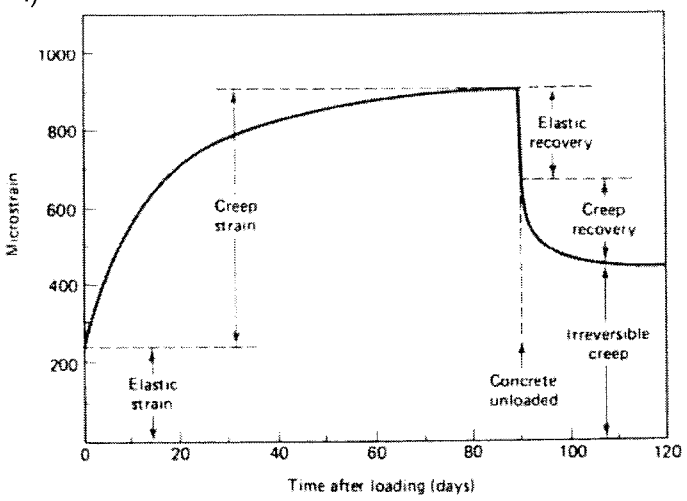
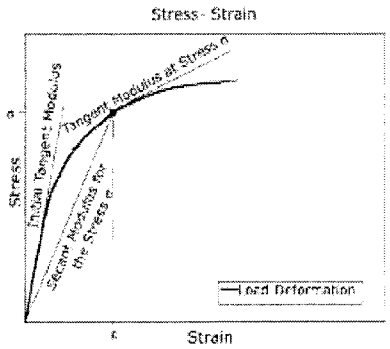
SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd Sem. 2019-20
Course Code: CIV 315
Course Name: ADVANCED CONCRETE TECHNOLOGY
Program & Sem: CIVIL ENGINEERING – 5TH Semester

Date: 24.12.2019
Time: 9:30 AM – 12:30 PM
Max Marks: 80
Weightage: 40%

Part A (0Q x 0M = 0Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	i)  ii) iii) Plastic Shrinkage, Drying shrinkage, Autogenous shrinkage, Carbonation shrinkage  iv) v) Creep vi) Poisson's ratio vii)Carbonation	2 per answer	60 min

	viii) accelerating admixtures are triethenolamine, calcium formate, silica fume, calcium chloride, finely divided silica gel etc. Calcium chloride is the cheap and commonly used accelerating admixture. Commonly used retarding admixture is calcium sulphate or gypsum. Starch, cellulose products, common sugar, salts of acids ix) Steel fibers and Polypropylene fibers. Aspect ratio of fibers is the ratio of length of the fiber to its least lateral dimension. x) used to test self compacting concrete.		

Part B (0Q x 0M = 0 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
2	• Concrete is relatively brittle, and its tensile strength is typically only about one tenths of its compressive strength. Regular concrete is therefore normally reinforced with distributed fibers. Their main purpose is to increase the energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete Factors that effect FRC • Relative Fiber Matrix Stiffness • Volume of Fibers • Aspect Ratio of the Fiber • Orientation of Fibers • Workability and Compaction of Concrete • Size of Coarse Aggregate • Mixing Orientation of fibers: • One of the differences between conventional reinforcement and fibre reinforcement is that in conventional reinforcement, bars are oriented in the direction desired while fibres are randomly oriented. • In one set specimens, fibres were aligned in the direction of the load, in another in the direction perpendicular to that of the load, and in the third randomly distributed. • It was observed that the fibres aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibres.	2 6 2	20 min

3	Self-compacting concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. *SCC HAVE FOLLOWING PROPERTIES-* • **Filling ability (excellent deformability)** – flows easily at suitable speed into formwork • **Passing ability (ability to pass reinforcement without blocking)** -passes through reinforcements without blocking • **High resistance to segregation-** the distribution of aggregate particles remains homogeneous in both vertical and horizontal directions Disadvantages of SCC • More precise measurement and monitoring of the constituent materials. • Requires more trial batches at laboratory as well as at ready-mixed concrete plants. • Costlier than conventional concrete based on concrete material cost (exception to placement cost). • Lack of globally accepted test standards and mix designs • More stringent requirements on the selection of materials • Formwork needed is airtight and uniform.	3 3 4	20 min
4	• Vacuum concrete is the one from which water is removed by vacuum pressure after placement of concrete in structural member. Vacuum concrete has high strength and durability than normal concrete. • In this process, excess water used for higher workability, not required for hydration, and harmful in many ways to the hardened concrete is withdrawn by means of vacuum pump, subsequent to the placing of the concrete. • The magnitude of applied vacuum is usually about 0.08 MPa and the water content is reduced by upto 20-25%. The reduction is effective upto a depth of about 100 to 150 mm only. • It essentially consists of a vacuum pump, water separator and filtering mat. The filtering consists of a backing piece with a rubber seal all round the periphery. • Filtering mat consists of a sheet of expanded metal and a sheet of wire gauge. • The top of the suction mat is connected to the vacuum pump. When the vacuum pump operates, suction is created within the boundary of the suction mat and the excess of water is sucked from the concrete through the fine wire gauge or muslin cloth.	5	20 min

	• One face of the concrete must be open to the atmosphere to create difference of pressure. The contraction of concrete caused by loss of water must be vibrated. Advantages of Vacuum concreting • Due to dewatering through vacuum, both workability and high strength are achieved simultaneously. • Reduction in water-cement ratio may increase the compressive strength by 10 to 15% and lowers the permeability. • It enhances the wear resistance of concrete surface. • The surface obtained after vacuum dewatering is plain and smooth due to reduced shrinkage. • The formwork can be removed early and surface can be put to use early.	5	

Part C (2Q x 15M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5	Step 1 — Determining The Target Strength For Mix Proportioning F'ck = fck + 1.65 x S Step 2 — Selection Of Water-Cement Ratio:- From Table 5 of IS 456, Maximum water-cement ratio = 0.50 Step 3 — Selection Of Water Content Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump) Step 4 – Calculation Of Cement Content Step 5: Proportion Of Volume Of Coarse Aggregate And Fine Aggregate Content From Table 3 of IS 10262- 2009, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone I) = 0.60 Step 6: Estimation Of Concrete Mix Calculations	3 2 2 2 3 3	30 min
6	*Step 1. Choice of slump* -- If slump is not specified, a value appropriate for the work can be selected from Table 6.3.1. The slump ranges shown apply when vi- bration is used to consolidate the concrete. Mixes of the stiffest consistency that can be placed efficiently should be used. *Step 2. Choice of maximum size of aggregate* -- Large nominal maximum sizes of well graded aggregates ***Step 3. Estimation of mixing water and air content -- The*** quantity of water per unit volume of concrete required to produce a given slump is	1 2 2	30 min

	dependent on: the nominal maximum size, particle shape, and grading of the aggregates; the concrete temperature; the amount of en- trained air; and use of chemical admixtures. Table 6.3.3 provides estimates of required mixing water for concrete made with various maximum sizes of aggregate, with and without air entrainment. Table 6.3.3 indicates the approximate amount of entrapped air to be expected in non-air-entrained concrete in the upper part of the table and shows the recommended average air content for air-entrained concrete in the lower part of the table. *Step 4. Selection of water-cement or water-cementitious materials ratio* -- The required *w/c* or *w/(c + p)* is determined not only by strength requirements but also by factors such as durability. Since different aggregates, cements, and cementitious materials generally produce dif- ferent strengths at the same *w/c* or *w/(c + p)*, In the absence of such data, approximate and relatively conservative values for concrete containing Type I portland cement can be taken from Table 6.3.4(a). For severe conditions of exposure, the *w/c* or *w/(c + p)* ratio should be kept low even though strength requirements may be met with a higher value. Table 6.3.4(b) gives limiting values. *Step 5. Calculation of cement content* -- The amount of cement per unit volume of concrete is fixed by the determinations made in Steps 3 and 4 above. The required cement is equal to the estimated mixing-water content (Step 3) divided by the water-cement ratio (Step 4). If, however, the specification includes a separate minimum limit on cement in addition to requirements for strength and durability, the mixture must be based on whichever criterion leads to the larger amount of cement. *Step 6. Estimation of coarse aggregate content* -- Aggregates of essentially the same nominal maximum size and grading will produce concrete of satisfactory workability when a given volume of coarse aggregate, on an oven-dry- rodded basis, is used per unit volume of concrete. Appropriate values for this aggregate volume are given in Table 6.3.6.	2 2 2	

	The volume of aggregate in ft3, on an oven-dry-rodded basis, for a yd3 of concrete is equal to the value from Table 6.3.6 multiplied by 27. 6.3.6.1 For more workable concrete, which is sometimes required when placement is by pump or when concrete must be worked around congested reinforcing steel, it may be desirable to reduce the estimated coarse aggregate content determined using Table 6.3.6 by up to 10 percent. *Step 7. Estimation of fine aggregate content* -- At completion of Step 6, all ingredients of the concrete have been estimated except the fine aggregate. Its quantity is determined by difference. Either of two procedures may be employed: the weight method (Section 6.3.7.1) or the absolute volume method (Section 6.3.7.2). *Step 8. Adjustments for aggregate moisture*	2 2	