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**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST 1

Sem & AY: Odd & 2019-20

Date: 30.09.2019

Course Code: CIV 318

Time: 9:30AM to 10:30AM

Course Name: RETROFIT AND REHABILITATION OF STRUCTURES

Max Marks: 40

Program & Sem: B.Tech. (CIV) & VII DE

Weightage: 20%

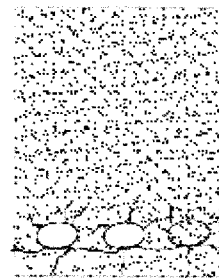
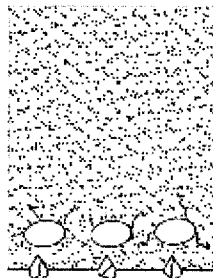
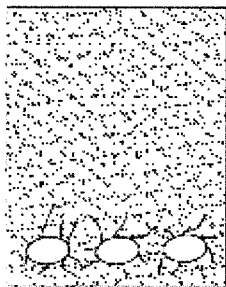
Instructions:

- (i) Read the question properly and answer accordingly
 - (ii) Scientific and Non-programmable calculators are permitted
-

Part A [Memory Recall Questions]

Answer all the Questions. Each question carries four marks. (3Qx4M=12M)

1. Freeze-Thaw cycles can cause rapid deterioration of concrete structures. Identify the factors influencing Freeze Thaw process? (C.O.NO.1) [Knowledge]
2. Shrinkage causes volumetric change in a concrete structure resulting in considerable cracking. Explain drying shrinkage process. (C.O.NO.1) [Knowledge]
3. Identify distress patterns in the given picture. Which is most critical? (C.O.NO.1) [Knowledge]



Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries six marks. (3Qx6M=18M)

4. Carbonation can be classified as chemical attack which affects the durability of concrete. Explain carbonation process? Also, list the factors influencing it.
(C.O.NO 1) [Knowledge]
5. Impervious structures are durable structures. Explain permeability. Identify the factors influencing it?
(C.O.NO 1) [Knowledge]
6. Per Holistic model II, there are three stages in deterioration of a structure. Draw a neat schematic to explain the propagation of damage per this model.
(C.O.NO 1) [Knowledge]

Part C [Problem Solving Questions]

Answer all the Questions. Each question carries five marks. (2Qx5M=10M)

7. Sulphate attack is one of the common types of chemical attack on concrete which affects the service life of a structure. Explain the process of sulfo-aluminate hydrate (ettringite) formation and why its determinantal to concrete.
(C.O.NO. 1) [Knowledge]
8. Poor choice of aggregates can significantly influence the durability of concrete structure by affecting the internal bond Explain Alkali Silica Reaction (AAR). What are the factors influencing it?
(C.O.NO 1) [Knowledge]



SCHOOL OF ENGINEERING

TEST – 1 SOLUTION

Semester: VII

Date: 30th Sep 2019

Course Code: CIV 318

Time: 1 Hour

Course Name: Retrofit and Rehabilitation of Structures

Max Marks: 40

Branch & Sem: B.Tech Civil, VII Sem, IV Year

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number / Unit/Module Title	Memory recall type [12 M] [Knowledge]	Thought provoking type [28 M] [Knowledge]	Problem solving type [0 M] [N/A]	Total Marks	
			K	K	-		
1	1	1 – Durability of Structure – Physical and Chemical Causes; Corrosion	4		-	4	
2	1		4		-	4	
3	1		4		-	4	
4	1				6	-	6
5	1				6	-	6
6	1				6	-	6
7	1				5	-	5
8	1				5	-	5
	Total Marks		12	28	0	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 Mr. Nakul Ramann]

SCHOOL OF ENGINEERING



GAIN MORE KNOWLEDGE
REACH GREATER HEIGHTS

TEST - 1 SOLUTION

Semester: VII

Course Code: CIV 318

Course Name: Retrofit and Rehabilitation of Structures

Branch & Sem: B.Tech Civil, VII Sem, IV Year

Date: 30-09-2019 (Mon)

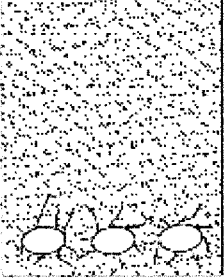
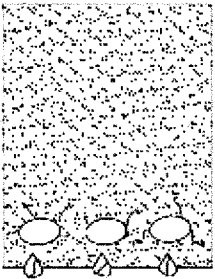
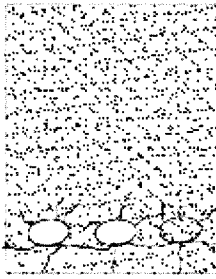
Time: 9:30 AM to 10:30 AM

Max Marks: 40

Weightage: 20%

Part A

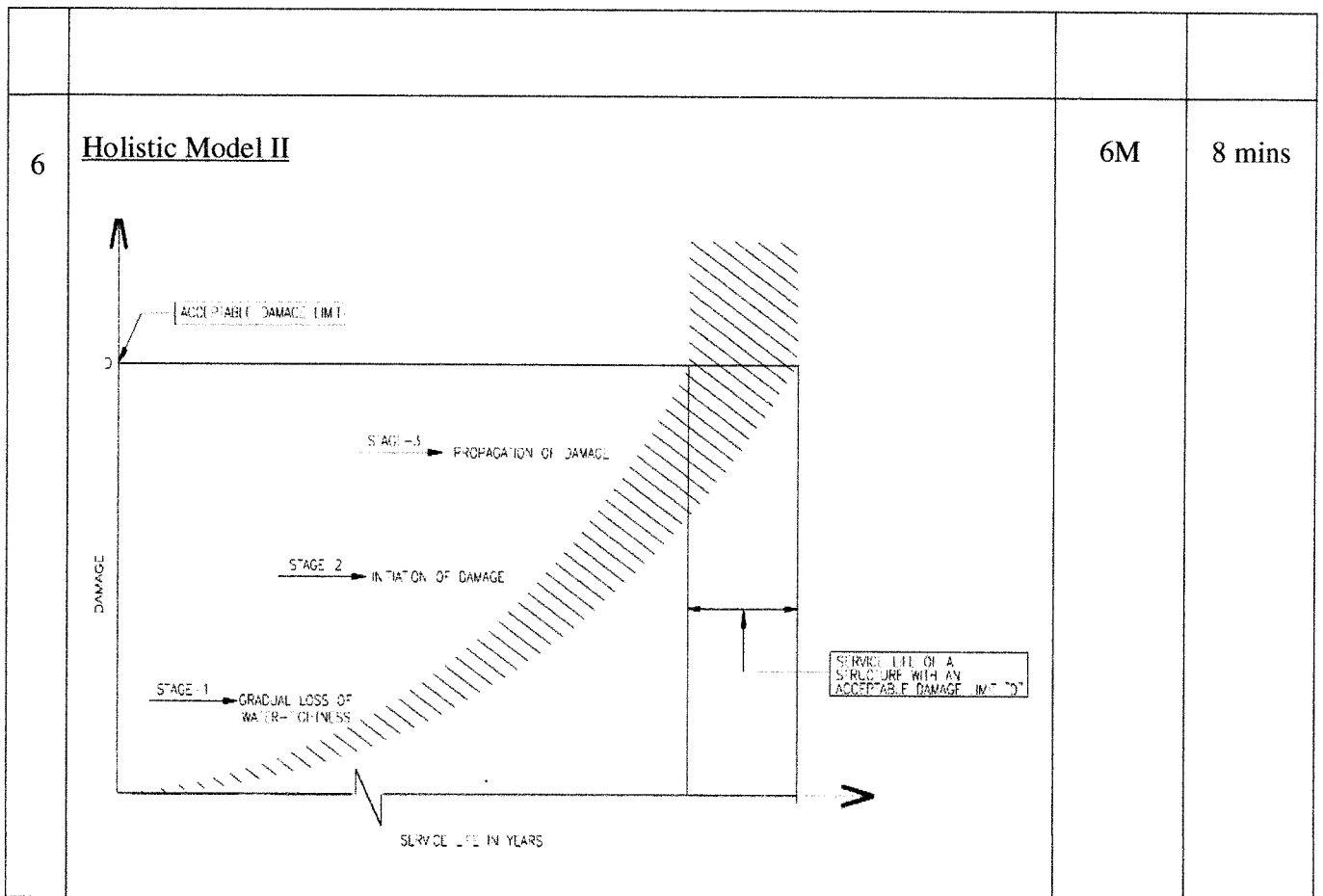
(3Q x 4M = 12 Marks)

Q No	Solution	Scheme of Marking	Max. Time for each Question
1	<p><u>Factors influencing Freeze-Thaw</u></p> <ul style="list-style-type: none"> • Water-cement ratio, Total water content • Air entrainment • Quality of aggregate • Curing conditions • Environmental conditions 	4M	5 mins
2	<p><u>Drying Shrinkage</u></p> <p>This is long-term change in volume of concrete caused by the loss of moisture either physical loss (evaporation) and / or chemical loss (hydration) during the hardening process, and exposure to unsaturated air. These cracks appear 7-10 days after concreting and around 80% of drying shrinkage takes place in about a year.</p> <p>Drying shrinkage is influenced by cement content, w/c ratio, aggregates, curing, humidity and temperature.</p>	4M	5 mins
3	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;">  <p>Radial cracking / Radial Fracture</p> </div> <div style="text-align: center;">  <p>Pop-Outs</p> </div> <div style="text-align: center;">  <p>Delamination / Debonding</p> </div> </div>	4M	5 mins

Part B

(3Q x 6M = 18 Marks)

Q No	Solution	Scheme of Marking	Max. Time for each Question
4	<p><u>Carbonation on Concrete:</u> Carbonation is defined as the reaction of CO₂ with the <u>hydrated</u> cement. Calcium hydroxide is converted to calcium carbonate by absorption of CO₂. Calcium carbonate is soluble in water and therefore when its formed, it tends to seal the surface pores of concrete. As a result, concrete surface becomes carbonated and changes the PH, which in turn will affect reinforcing steel. Concrete of good quality carbonates very slowly (5-10 mm in 50 years).</p> <p><u>Factors influencing carbonation:</u></p> <ul style="list-style-type: none"> • Time – Rate decreases with increasing time of exposure to air • Cover to reinforcement – Greater the cover, better the protection • Concentration of CO₂ in atmosphere: Rate increases with increasing CO₂ in air. • Permeability of concrete – Depends on concrete quality; carbonation depth increases by four times when the w/c ratio is increased from 0.4 to 0.8 • Alkali content in concrete – Depends on cement content and type of cement. • Condition of concrete cover: Any imperfection in cover such as segregation, poor compaction or cracking enables carbonation to progress more rapidly 	6M	8 mins
5	<p><u>Permeability of Concrete</u> is a good measure of Durability. Permeability determines moisture and air ingress, corrosion of steel, cracking and spalling of cover concrete, thermal-insulation properties.</p> <p><u>Factors influencing permeability:</u></p> <ul style="list-style-type: none"> • w/c ratio • curing period • Cover to reinforcement • Cement content and its properties • Aggregates • Mix design • Workability • Admixtures • Thermal incompatibility of concrete constituents • Transition zone between aggregate and cement matrix • Environmental conditions 	6M	8 mins



Part C

(2Q x 5M = 10 Marks)

Q No	Solution	Scheme of Marking	Max. Time for each Question
7	<p>Sulphate Attack:</p> <p>Sulphates are found in most soils as calcium, potassium, sodium and magnesium sulphates. Solid salts do not attack concrete, but when present in solution they can react with hardened cement paste. Sulphates are present in seawater, industrial effluents and some ground water.</p> <p>Sulphate attack is indicated by characteristic whitish appearance on the surface. Sulphate converts calcium hydroxide into large volume of calcium sulphate. The second hydration product tricalcium aluminate hydrate reacts with sulphate solution to form sulpho aluminate hydrate (ettringite) which has a greater volume than original compound and causes cracking.</p>	5M	8 mins

8	<p><u>Alkali reaction on concrete</u></p> <p>The reaction of some forms of silica and carbonates in aggregates with the alkali in cement produces a gel, which causes expansion and cracks. Moisture content around 80% and relative humidity at 21 o 24 °C is detrimental. Portland cement concrete made with non-alkali aggregates is highly resistant to strong solutions of most bases (sodium or potassium hydroxides).</p> <p>Visual inspection of affected areas will generally show map or pattern cracking with concrete swelling appearance.</p> <p>The presence of alkali-silica reaction (ASR) is confirmed by Petrographic examination of concrete.</p> <p><u>Factors influencing AAR/ASR</u></p> <ul style="list-style-type: none"> • Size of aggregate particles • Porosity of aggregate particles • Alkali content in cement • Fineness of cement particles • Availability of non-evaporable water in the paste • Alternate wetting and drying of concrete • Temperature – 10 to 40°C accelerates the reaction 	5M	8 mins
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Roll No.

**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20

Course Code: CIV 318

Course Name: RETROFIT AND REHABILITATION OF STRUCTURES

Program & Sem: B.Tech (Civil) & VII (DE)

Date: 18.11.2019

Time: 9:30 AM to 10:30 AM

Max Marks: 40

Weightage: 20%

Instructions:

- (i) Read the question properly and answer accordingly
- (ii) Scientific and Non-programmable calculators are permitted

Part A (Memory Recall Questions)

Answer all the Questions. Each question carries four marks. (3Qx4M=12M)

1. Polymer modified concrete/mortars also referred as PMC/PMM is a cheap and effective repair material. List its physical and mechanical properties.
(C.O.NO.2)[Knowledge]
2. Shotcrete is one of the repair methods available for carrying out the structural repairs to a distressed structure. What is Shotcrete? Explain the two methods of shotcreting.
(C.O.NO.4)[Knowledge]
3. Epoxy is one of the most versatile repair materials available for concrete members. Why should precautions be taken while using epoxy systems?
(C.O.NO.2)[Knowledge]

Part B (Thought Provoking Questions)

Answer all the Questions. Each question carries six marks. (3Qx6M=18M)

4. Fiber wrapping technique is also called Composite Fiber System. Explain types of fiber wraps available. Demonstrate its application with a sketch.
(C.O.NO.4)[Comprehension]

5. Non-Destructive Test (NDT) is a qualitative assessment of uniformity and integrity of a structure. Explain any two NDT methods. (C.O.NO.3)[Comprehension]

6. Plate bonding is an inexpensive, versatile and advanced technique for rehabilitation. Explain plate bonding method of strengthening with schematic? (C.O.NO.4)[Comprehension]

Part C (Problem Solving Questions)

Answer the Question. The Question carry ten marks. (1Qx10M=10M)

7. With a neat schematic show the following:
- Beam strengthening by section enlargement.
 - Stitching method of repair wall and slab

(C.O.NO.4)[Comprehension]



SCHOOL OF ENGINEERING

TEST – 2 SOLUTION

Semester: VII, DE

Date: 18-11-2019

Course Code: CIV 318

Time: 9:30 AM to 10:30 AM

Course Name: RETROFIT AND REHABILITATION OF STRUCTURES

Max Marks: 40

Branch & Sem: B.Tech Civil, VII Sem, IV Year

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number / Unit/Module Title	Memory recall type [12 M] [Knowledge]	Thought provoking type [18 M] [Comprehension]	Problem solving type [10 M] [Comprehension]	Total Marks
			K	C	C	
1	2	2 – NDT Test Methods	4			4
2	3		4			4
3	2		4			4
4	4	3 - Repair Materials and Methods		6		6
5	3			6		6
6	3			6		6
7	4				10	10
Total Marks			12	18	10	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 hereby certify that all the questions are set as per the above guidelines. [Dr. Nakul .R]

Reviewer's Comments:



SCHOOL OF ENGINEERING

TEST - 2 SOLUTION

Semester: VII

Course Code: CIV 318

Course Name: RETROFIT AND REHABILITATION OF STRUCTURES

Branch & Sem: B.Tech Civil, VII Sem, IV Year

Date: 18-11-2019

Time: 9:30 AM to 10:30 AM

Max Marks: 40

Weightage: 20%

Part A

(3Q x 4M = 12 Marks)

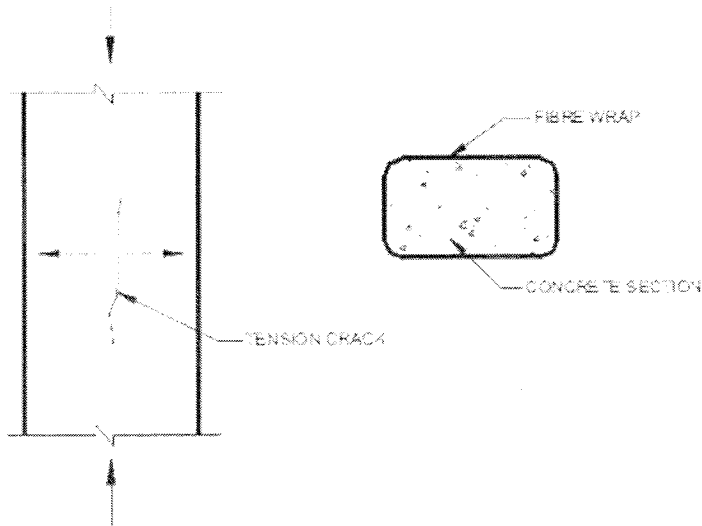
Q No	Solution	Scheme of Marking	Max. Time for each Question
1	<p>Admixing of polymer latex in cementitious mixtures modifies the following physical and mechanical properties:</p> <ol style="list-style-type: none">1. Better Workability2. Improved water retention3. Better resistance to Bleeding and Segregation4. Increased Resistance to Crack Propagation5. Better tensile and flexural Strength6. Chemical resistance of PMM/PMC7. Temperature effect: Rapid reduction in strength with increase in temperature.8. Shrinkage: More is the polymer ratio, lesser is drying shrinkage9. Water proofing Quality or low permeability10. Improved adhesion or bond strength11. Better Abrasion Resistance12. Better Durability and non-degradability	4M	5 mins
2	<p>Shotcrete is defined as pneumatically applied concrete or mortar placed directly on to a surface. The shotcrete shall be placed by either the dry mix or wet mix process.</p> <p>The <i>dry mix</i> process shall consist of</p> <ol style="list-style-type: none">1. Thoroughly mixing the dry materials,2. Feeding of these materials into mechanical feeder or gun,3. Carrying the materials by compressed air through a hose to a special nozzle,4. Introducing water at nozzle point and intimately mixing it with other ingredients at the nozzle;5. Jetting the mixture from the nozzle at high velocity on to the surface to receive the shotcrete <p>The <i>wet mix</i> process is the same as above except Step 4 (as water is already introduced to the mix)</p>	4M	5 mins

3	<p>Epoxies are generally toxic in nature and these require lot of care in their handling. The special care required to be taken during their mixing and applications are as under:</p> <ol style="list-style-type: none"> 1. They should not come in contact with the skin. Workers should be provided with rubber gloves. 2. The utensils/ equipment used for the mixing resin and hardener should be cleaned immediately after their use. 3. The pot life of the mixed epoxy is generally very limited, ½ to 2 hours. It should be finally applied as adhesive within pot life period. Therefore, material should be prepared just sufficient to cover the area within the pot life period as recommended by the manufacturers. 4. The epoxies are generally used as an adhesive to act as bond coat between the old concrete and repaired concrete. The epoxies have a glass transition range at temperatures at 60 to 80o C depending upon the epoxy type. Therefore, they should not be used in the exposed environment. 5. Epoxies have much higher bond strength than other polymers, but at the same time, these are costlier. 	4M	5 mins

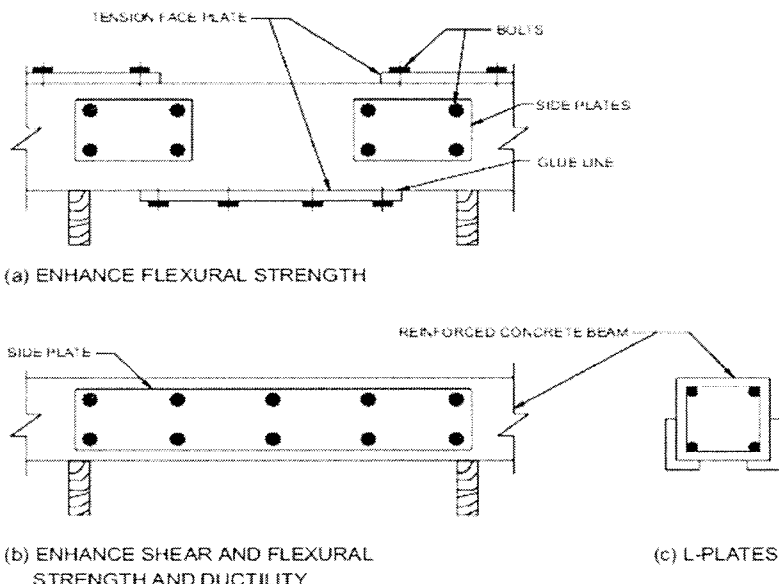
Part B

(3Q x 6M = 18 Marks)

Q No	Solution	Scheme of Marking	Max. Time for each Question
4	<p>The fibre wrap technique, also known as Composite Fiber System, is a non-intrusive structural strengthening technique that increases the load carrying capacity (shear, flexural, compressive) and ductility of reinforced concrete members without causing any destruction or distress to the existing concrete.</p> <p>There are two systems followed in adopting this technique</p> <ol style="list-style-type: none"> 1. <u>Bi-directional Woven Fabric</u> - Woven fibre fabric is composed of bi-directional high strength fibers that are combined with specially formulated epoxy in a pre-determined proportion to form a composite-Material. 2. <u>Uni-directional E-glass Fibres</u>: This system comprises of precut unidirectional E-glass fibre wrapped over epoxy primer applied prepared surface of member requiring structural strengthening and/or surface protection 	<p>6M</p> <p>(3M explan.; 3M fig)</p>	10 mins

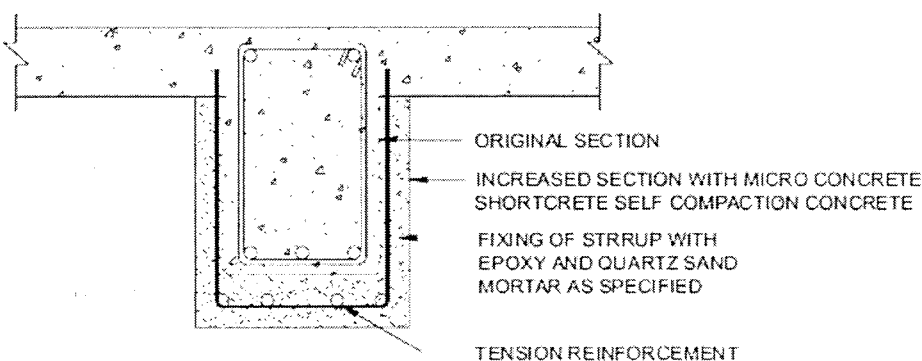


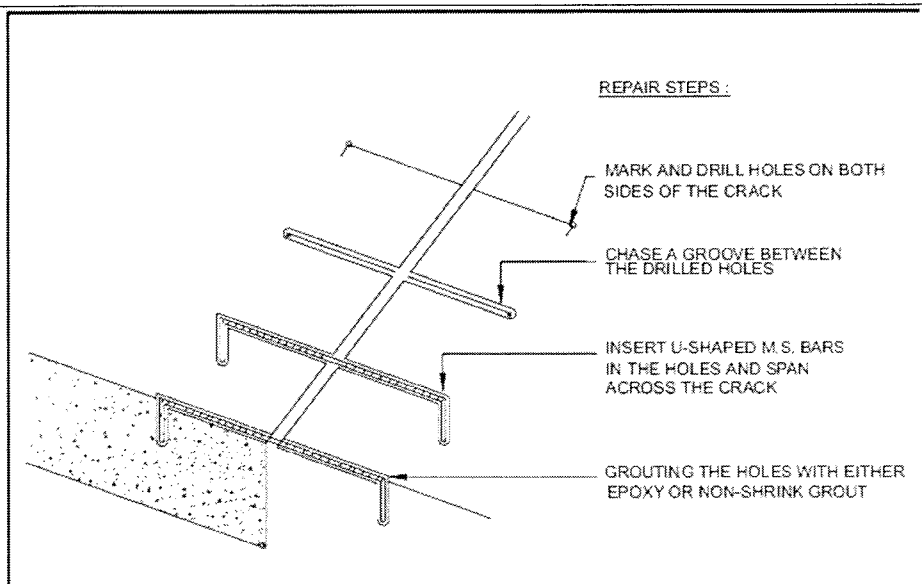
5	<p>The operation of Rebound Hammer (also called Schmidt's Hammer) - When the plunger of rebound hammer is pressed against the surface of concrete, a spring-controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as Rebound Number (a rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value. The results are significantly affected by Mix characteristics, Angle of Inclination of direction of hammer with reference to horizontal, and Member Characteristics.</p> <p>Ultrasonic scanning is a recognized non-destructive evaluation test to qualitatively assess the homogeneity and integrity of concrete. With this technique, following can be assessed.</p> <ol style="list-style-type: none"> 1. Qualitative assessment of strength of concrete, its gradation in different locations of structural members and plotting the same 2. Any discontinuity in cross section like cracks, cover concrete delamination etc 3. Depth of surface cracks <p>The pulse velocity in concrete may be influenced by:</p> <ol style="list-style-type: none"> 1. Path length 2. Lateral dimensions of the specimen tested. 3. Presence of reinforcing steel 4. Moisture content of the concrete. 	6M (3M per method)	10 mins
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6	<p>Plate bonding is an inexpensive, versatile and advanced technique for rehabilitation, up gradation of concrete structures by mechanically connecting MS plates by bolting and gluing to their surfaces with epoxy as shown in Fig. Plate bonding can substantially increase strength, stiffness, ductility and stability of the reinforced concrete elements and can be used effectively for seismic retrofitting.</p>  <p>(a) ENHANCE FLEXURAL STRENGTH</p> <p>(b) ENHANCE SHEAR AND FLEXURAL STRENGTH AND DUCTILITY</p> <p>(c) L-PLATES</p>	6M (1M explan.; 5M fig)	10 mins
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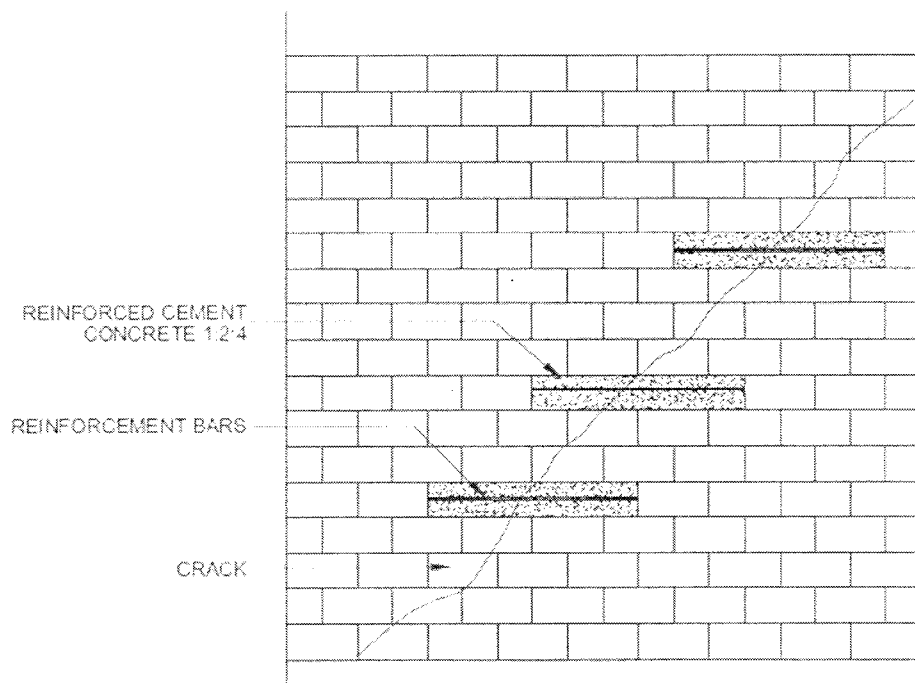
Part C

(1Q x 10M = 10 Marks)

Q No	Solution	Scheme of Marking	Max. Time for each Question
7	 <p>BEAM SECTION ENLARGEMENT</p> <p>ORIGINAL SECTION</p> <p>INCREASED SECTION WITH MICRO CONCRETE/ SHORTCRETE SELF COMPACTION CONCRETE</p> <p>FIXING OF STRRUP WITH EPOXY AND QUARTZ SAND MORTAR AS SPECIFIED</p> <p>TENSION REINFORCEMENT</p>	10M	15 mins



Stitching method of repairing slab



Stitching method of repairing wall



Roll No																			
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**PRESIDENCY UNIVERSITY
BENGALURU**
SCHOOL OF ENGINEERING
END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20

Course Code: CIV 318

Course Name: RETROFIT AND REHABILITATION OF STRUCTURES

Program & Sem: B.Tech (CIV) & VII (DE-IV)

Date: 24 December 2019

Time: 9:30 AM to 12:30 PM

Max Marks: 80

Weightage: 40%

Instructions:

- (i) Read questions carefully and answer accordingly.
- (ii) Scientific and Non-programmable calculator permitted

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 4 marks.

(5Qx4M=20M)

1. Freeze-Thaw cycles can cause rapid deterioration of concrete structures. Identify the factors influencing Freeze Thaw process? (C.O.No.1)[Knowledge]
2. It is recommended for repair materials to have compatible mechanical properties and strength. Give reasons. (C.O.No.2)[Knowledge]
3. Foundation rehabilitation is critical for foundations in distress or in cases of poor soil-structure interaction. Briefly explain various methods for Foundation Rehabilitation? (C.O.No.3)[Knowledge]
4. What is Near Surface Mount (NSM) method of retrofitting? List the disadvantages. (C.O.No.4)[Knowledge]
5. For the given figure 1, recommended the groove (or slot) dimensions if the CFRP strip reinforcement is 2mm x 6mm and the FRP bar is 6mm diameter. (C.O.No.4)[Knowledge]

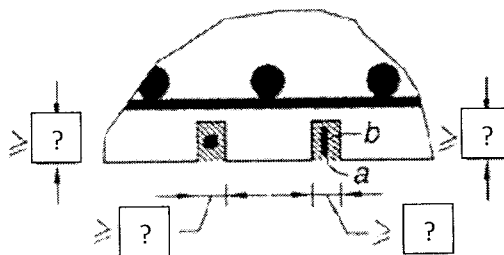


Figure 1

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 6 marks.

(5Qx6M=30M)

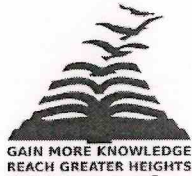
6. Corrosion process can be physical, chemical and electrochemical in nature. Explain the corrosion process. What are the preventive methods? (C.O.No.1)[Comprehension]
7. Carbonation can be classified as chemical attack which affects the durability of concrete. Explain carbonation process? Also, list the factors influencing it. (C.O.No.1)[Comprehension]
8. With a neat schematic show the simplified model of Process of Polymer film formation on Cement hydrates. (C.O.No.3)[Comprehension]
9. Give the repair procedure for the following Case - RCC Slabs, where carbonation depth has reached reinforcement level (C.O.No.4)[Comprehension]
10. Explain Beam repair by Guniting method with a neat sketch. (C.O.No.4)[Comprehension]

Part C [Problem Solving Questions]

Answer all the Questions. Each Question carries 10 marks.

(3Qx10M=30M)

11. Sulphate attack is one of the common types of chemical attack on concrete which affects the service life of a structure. Explain the process of sulpho-aluminate hydrate (ettringite) formation and why it's detrimental to concrete. (C.O.No.1)[Comprehension]
12. Chemical analysis of concrete can provide extremely useful information regarding the causes of failure of concrete. List various chemical test methods. Explain any two. (C.O.No.2)[Comprehension]
13. Poor choice of aggregates can significantly influence the durability of concrete structure by affecting the internal bond. Explain Alkali Aggregate Reaction (AAR). Explain the factors influencing it? (C.O.No.2)[Comprehension]



SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

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 Level	Thought provoking type [Marks allotted] Bloom's Level	Problem Solving type [Marks allotted] Bloom's Level	Total Marks
			K	C	A	
1	CO1	Module 1	4			4
2	CO2	Module 1	4			4
3	CO3	Module 2	4	4		4
4	CO4	Module 4	4	4		4
5	CO4	Module 4	4			4
6	CO1	Module 1		6		6
7	CO1	Module 1		6		6
8	CO3	Module 3		6		6
9	CO4	Module 3		6		6
10	CO4	Module 3		6		6
11	CO1	Module 1		10		10
12	CO2	Module 1		10		10
13	CO2	Module 1		10		10
Total Marks			12 20	68 60	0	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 Comment:



SCHOOL OF ENGINEERING

SOLUTION

Semester: Odd Sem. 2019-20

Course Code: CIV 318

Course Name: Retrofit and Rehabilitation of Structures

Program & Sem: B.Tech (Civil), VII, DE - IV

Date: 24.12.2019

Time: 9:30 AM to 12:30 PM

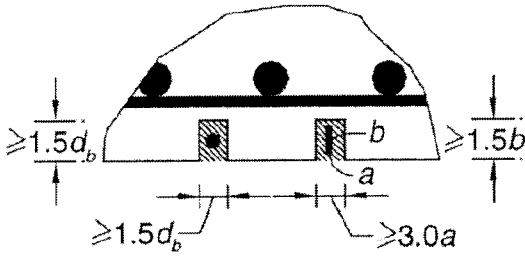
Max Marks: 80

Weightage: 40%

Part A

(5Q x 4M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1	<p><u>Factors influencing Freeze-Thaw</u></p> <ul style="list-style-type: none"> • Water-cement ratio, Total water content • Air entrainment • Quality of aggregate • Curing conditions • Environmental conditions 	4M	5 min
2	<p>The hardened material shall have compatible mechanical properties or rather slightly better strength than that of base material. This property is desirable to ensure uniform flow of stresses and strains in loaded structures. It is well known that the elastic modulus of two concretes would be different for different crushing strength so if repair concrete is having strength much different than the base, it could lead to non-uniform flow of stresses and may result in an early failure of the repair patch. For example, if M-20 grade of concrete has been used in original Repairs & Rehabilitation Unit construction, the grade of the repair material shall neither be less than M-20 nor higher than M-25.</p>	4M	6 min
3	<p><u>Foundation Rehabilitation Methods:</u></p> <ol style="list-style-type: none"> 1. <u>Shoring</u> – Before this work is commenced, building should be carefully surveyed and records of levels, cracks and tilts be kept. <ul style="list-style-type: none"> • <u>Raking Shores</u> – With the angle of shores 60 – 75 are usually used where external support is necessary. • <u>Flying shores</u> – Merely provide a restraint against building or tilting. Feet of the shores doesn't touch the ground. • <u>Dead Shores</u> – Verified struts bearing on the ground at required distance and supporting the vertical load of a wall wherever required in conjunction with flying shores or horizontal ties. 2. <u>Underpinning</u> – Essential to arrest settlement. Foundation should meet the requirements of correct allowable bearing pressures. Types 	4M	5 min

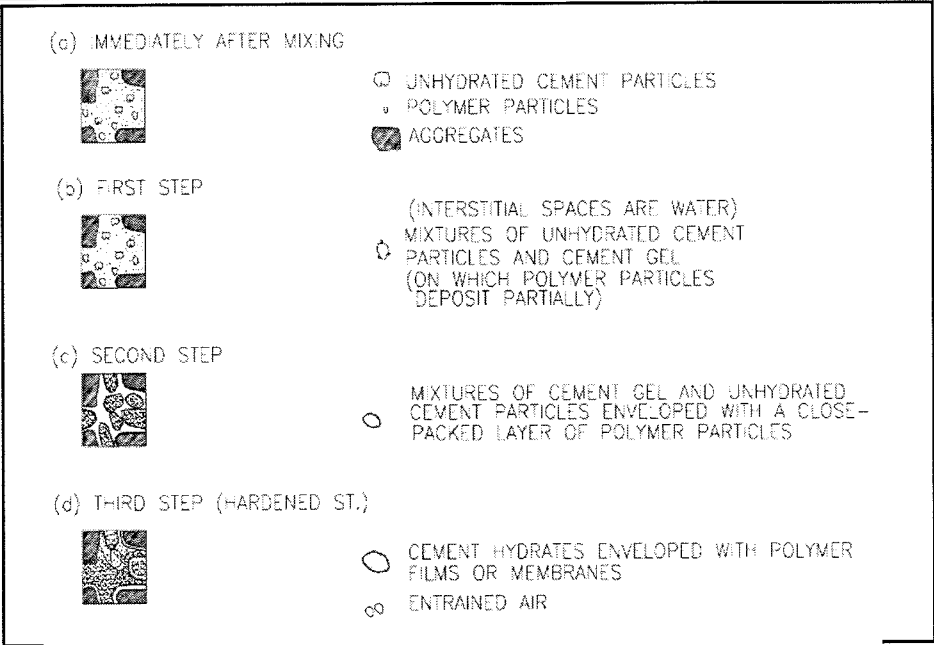
	include Underpinning piles, Micro-piles, Proprietary jacked piles, underpinning by injection of the ground with cement or chemicals.				
4	<p><u>Near Surface Mount (NSM)</u> of retrofitting involves making grooves on the concrete surface, as shown in Qn. 5 Schematic, and embedding reinforcement materials such as bar to strip made with FRP or steel. Epoxy secures the reinforcement in place and it can be 3-side bonded or 4-side bonded.</p> <p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> • It's labour intensive • Requires skilled labour, engineer expertise and specialized equipment • More expensive than conventional retrofitting methods • Reinforcement material such as CFRP material, epoxy etc must be locally available. 	4M	6 min		
5	 <table border="1" data-bbox="279 1030 1204 1187"> <tr> <td><u>Groove dimensions for CFRP Strip</u> Width $\geq 3 \cdot a \geq 3 \cdot 2 \geq 6\text{mm}$ Depth $\geq 1.5 \cdot b \geq 1.5 \cdot 6 = 9\text{mm}$</td> <td><u>Groove dimensions for FRP Bar</u> Width and Depth $\geq 1.5 \cdot b \geq 1.5 \cdot 6 = 9\text{mm}$</td> </tr> </table>	<u>Groove dimensions for CFRP Strip</u> Width $\geq 3 \cdot a \geq 3 \cdot 2 \geq 6\text{mm}$ Depth $\geq 1.5 \cdot b \geq 1.5 \cdot 6 = 9\text{mm}$	<u>Groove dimensions for FRP Bar</u> Width and Depth $\geq 1.5 \cdot b \geq 1.5 \cdot 6 = 9\text{mm}$	4M	5 min
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Part B

(5Q x 6M = 30 Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
6	<p><u>Corrosion:</u> Concrete is highly alkaline material with pH between 12 and 13. In this range, embedded steel is protected from corrosion by a passivating film bonded to the reinforcing bar surface. However, when this film is disrupted, corrosion takes place. Nature of corrosion mechanism can be attributed to chemical, electrochemical and physical.</p> <ul style="list-style-type: none"> • It is chemical in the sense that the alkalinity of concrete can get reduced to a pH level of less than 10 by the ingress of carbon dioxide or the passivity of steel can be destroyed by the ingress of chloride thereby initiating corrosion process. • It is electrochemical in the sense that the galvanic cells get established by forming locally or generally cathodic and anodic sites resulting in the flow of current with concrete serving as electrolyte. In this process the rate of corrosion is influenced by oxygen supply. • It is physical in the sense that as the corrosion process progresses; the corrosion product (rust) experiences volume growth as high as six to 	6M	15 min

	<p>seven times the original corroding metal, resulting in spalling of concrete and exposure of reinforcement.</p> <p><u>Preventive Methods:</u></p> <ul style="list-style-type: none"> • Use of low permeable concrete • Use of properly proportioned concrete having low w/c ratio • Use of a low concrete slump as practical • Use of good workmanship in placing concrete • Curing concrete properly • Providing adequate concrete cover • Good drainage • Limiting chlorides in concrete mixture 		
7	<p><u>Carbonation on Concrete:</u> Carbonation is defined as the reaction of CO₂ with the <u>hydrated</u> cement. Calcium hydroxide is converted to calcium carbonate by absorption of CO₂. Calcium carbonate is soluble in water and therefore when its formed, it tends to seal the surface pores of concrete. As a result, concrete surface becomes carbonated and changes the PH, which in turn will affect reinforcing steel. Concrete of good quality carbonates very slowly (5-10 mm in 50 years).</p> <p><u>Factors influencing carbonation:</u></p> <ul style="list-style-type: none"> • Time – Rate decreases with increasing time of exposure to air • Cover to reinforcement – Greater the cover, better the protection • Concentration of CO₂ in atmosphere: Rate increases with increasing CO₂ in air. • Permeability of concrete – Depends on concrete quality; carbonation depth increases by four times when the w/c ratio is increased from 0.4 to 0.8 • Alkali content in concrete – Depends on cement content and type of cement. • Condition of concrete cover: Any imperfection in cover such as segregation, poor compaction or cracking enables carbonation to progress more rapidly. 	6M	15 min

8	 <p>(a) IMMEDIATELY AFTER MIXING</p> <p>(b) FIRST STEP</p> <p>(c) SECOND STEP</p> <p>(d) THIRD STEP (HARDENED ST.)</p>	6M	15 min
9	<p>(i) Repair with polymer modified cement mortar (For patch repairs or repairs over smaller magnitude)</p> <p>Step-1: Propping and supporting of RCC slab under distress.</p> <p>Step-2: All loose and spalled cover concrete shall be removed including finishing plaster wherever found loose by tapping.</p> <p>Step-3: The rusted reinforcement shall be cleaned of concrete preferably by using sand blasting to give a minimum 15 mm clear air gap all around including behind the reinforcement.</p> <p>Step-4: Additional reinforcement wherever necessary shall be added and tied to the RCC slab with necessary binding wires and nails.</p> <p>Step-5: Fix shear key bars of appropriate diameter at specified spacings in both directions over the surface to be covered with repair.</p> <p>Step-6: The rusted reinforcement shall be cleaned of rust and passivated and applied bond.</p> <p>Step-7: The prepared concrete surface shall be covered with appropriate mix of polymer modified cement sand mortar in layers including behind reinforcement over a bond coat with polymer modified cement slurry. The mortar cover thickness shall be not less than 15 mm over the reinforcement. The maximum thickness shall be not more than 30 mm with each layer not exceeding 10 mm.</p> <p>Step-8: Water curing shall be carried out for a minimum period of 7 days.</p> <p>Step-9: Necessary white washing /painting of the surface may be carried out after the curing period is over and the surface gets dried up.</p> <p><u>OR</u></p> <p>(ii) Shotcreting: (For repair jobs covering large areas and / or large magnitude)</p> <p>Step-1: Step no. 1 to 6 shall be same as in case of no. (i) above.</p> <p>Step-7: Shotcreting with average thickness of 50 mm shall be done within the tacking period of epoxy bond coat to be applied over the prepared surface of concrete.</p> <p>Step-8: Finishing plaster if necessary, may be provided within 48 hours of</p>	6M	15 min

	shotcreting without allowing the RCC slab to become dry during the intervening period. Step-9: Water curing shall be carried out for a minimum period of 7 days.		
10	<p>STAGE 1: GUNITE SHOTCRETE</p> <p>STAGE 2: GUNITE SHOTCRETE, TIMBER FORMWORK AND CROSS FRAMING</p> <p>STAGE 3: SHUTTER FINISHED SURFACE (TIMBER FORMWORK REMOVED), PREVIOUSLY GUNITE SHOTCRETE SURFACE, SECOND STAGE GUNITE SHOTCRETE</p> <p>(A) BEAM REPAIR</p>	6M	15 min

Part C

(3Q x 10M = 30Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
11	<p><u>Sulphate Attack:</u> Sulphates are found in most soils as calcium, potassium, sodium and magnesium sulphates. Solid salts do not attack concrete, but when present in solution they can react with hardened cement paste. Sulphates are present in seawater, industrial effluents and some ground water. Sulphate attack is indicated by characteristic whitish appearance on the surface. Sulphate converts calcium hydroxide into large volume of calcium sulphate. The second hydration product tricalcium aluminate hydrate reacts with sulphate solution to form sulpho-aluminate hydrate (ettringite) which has a greater volume than original compound and causes cracking.</p>	10M	20 min
12	<p><u>Chemical Tests</u></p> <ol style="list-style-type: none"> 1. Depth of carbonation 2. Chloride content 3. Cement content 4. Sulphate content 5. Type of cement 6. Alkali content <p><u>Carbonation Test:</u> This test is carried out to determine the depth of concrete affected due to combined attack of atmospheric carbon dioxide and moisture causing a reduction in level of alkalinity of concrete. A spray of 0.2% solution of phenolphthalein is used as pH indicator of concrete. The change of colour of concrete to pink indicates that the concrete is in the good health, where no change in colour takes place, it is suggestive of carbonation-affected concrete. The test is conducted by drilling a hole on the concrete surface to different depths upto cover concrete thickness, removing dust by air blowing, spraying phenolphthalein with physician's injection syringe and needle on such freshly drilled/ broken concrete and observing the colour change. The depth of carbonation is estimated based on the change in colour profile.</p> <p><u>Chloride Content:</u> Chloride content can be determined from broken samples or core samples of concrete. Primarily, the level of chloride near the steel-concrete interface is of prime importance. "Rapid chloride test kit-4" - The test consists of</p>	10M	15 min

	obtaining powdered samples by drilling and collecting them from different depths (every 5 mm), mixing the sample (of about 1.5 gm weight) with a special chloride extraction liquid, and measuring the electrical potential of the liquid by chloride-ion selective electrode. With the help of a calibration graph relating electrical potential and chloride content, the chloride content of the samples can be directly determined.		
13	<p><u>Alkali reaction on concrete</u></p> <p>The reaction of some forms of silica and carbonates in aggregates with the alkali in cement produces a gel, which causes expansion and cracks. Moisture content around 80% and relative humidity at 21 o 24 °C is detrimental. Portland cement concrete made with non-alkali aggregates is highly resistant to strong solutions of most bases (sodium or potassium hydroxides).</p> <p>Visual inspection of affected areas will generally show map or pattern cracking with concrete swelling appearance. Petrographic examination in accordance with ASTM C295 can be used to confirm alkali-carbonate reaction (or AAR).</p> <p><u>Factors influencing AAR</u></p> <ul style="list-style-type: none"> • Size of aggregate particles • Porosity of aggregate particles • Alkali content in cement • Fineness of cement particles • Availability of non-evaporable water in the paste • Alternate wetting and drying of concrete • Temperature – 10 to 40°C accelerates the reaction 	10M	20 min

