UNIT-I

2 Marks

1. Define Maintenance.

Maintenance is the act of keeping something in good condition by checking or repairing it regularly.

2. Define Repair.

Repair is the process of restoring something that is damaged or deteriorated or broken, to good condition.

3. Define Rehabilitation.

Rehabilitation is the process of returning a building or an area to its previous good conditions.

4. What are the two facets of maintenance?

The two facets of maintenance are

i) Prevention

ii) Repair

5. What are the causes of deterioration?

i) Deterioration due to corrosion

ii) Environmental effects

iii) Poor quality material used

iv) Quality of supervision

v) Design and construction flaws

6. Define physical inspection of damaged structure.

Some of the use full in formation may be obtained from the physical inspection of damaged structure, like nature of distress, type of distress, extent damage and its classification etc, their causes preparing and documenting the damages, collecting the samples for laboratory testing and analysis, planning for in situ testing, special

environmental effects which have not been considered at the design stage and information on the loads acting on the existing structure at the time of damage may be, obtained. To stop further damages, preventive measure necessary may be planned which may warrent urgent execution.

7. How deterioration occurs due to corrosion?

- Spalling of concrete cover
- Cracks parallel to the reinforcement
- Spalling at edges
- Swelling of concrete
- Dislocation
- Internal cracking and reduction in area of steel reinforcement.

8. What are the steps in selecting a repair procedure?

- Consider total cost
- Do repair job in time
- If defects are few & isolated repair on an individual basis. Otherwise do in generalized manner
- Ensure the repair prevents further development of defects
- Incase of lost strength, repairs should restore the strength
- If appearance is a problem, the number of applicable types of repairs become limited & the repairs must be covered
- Repair works should not interface with facilities of the structure
- Take care in addition of section to a member and in restributing live loads and other live load moments. After selecting a suitable method of repairs, and after considering all the ramifications of its application, the last step is to prepare plans & specification and proceed with the work.

9. Discuss about the environment effects which leads to deterioration of concrete structure.

Micro-cracks present in the concrete are the sources of ingress of moistures atmospheric carbon di-oxide into the concrete which attack reinforcement and with

various ingredients of concrete. In aggressive environme4nt concrete structure will be severely reduces.

10. What is the effect of selecting poor quality material for construction?

Quality of materials, to be used in construction, should be ensured by means various tests as specified in the IS codes. Alkali-aggregate reaction and sulphate attack results in early deterioration. Clayey materials in the fine aggregates weaken the mortar aggregate bond and reduce the strength. Salinity causes corrosion of reinforcing bars as well as deterioration of concrete.

11. How can we determine the cause for deterioration of concrete structure?

a) Inspect & observe the structure
b) Observe in bad & good weather
c) Compare with other constructions on the area or elsewhere & be patient
d) Study the problem & allow enough time to do the job

12. What are the factors to be considered by the designer at the construction site.

⇒ Minimum and maximum temperatures
⇒ temperature cycles
⇒ exposure to ultra violet radiation
⇒ amount of moisture
⇒ wet/dry cycles
⇒ presence of aggressive chemicals

13. What are the steps in repair aspect?

i. finding the deterioration
ii. determining the cause
iii. evaluating the strength of existing building or structure
iv. evaluating the need of repair
v. Selecting & implementing a repair procedure

14. Define the fixed percentage method of evaluating the strength of existing structure.

It is to assume that all members which have lost less than some predetermined % of their strength are still adequate and that all members which have lost more than the strength are inadequate. It is usually from 15% onwards higher values are applicable for piling % stiffness bearing plates etc.

15. Discuss about the design and construction errors leading to deterioration of a structure.

Design of concrete structures governs the performance of concrete structures. Well designed and detailed concrete structure will show less deterioration in comparison with poorly designed and detailed concrete, in the similar condition. The beam-column joints are particularly prone to defective concrete, if detailing and placing of reinforcement is not done properly. Inadequate concrete cover may lead to carbonation depth reaching up to the reinforcement, thus, increasing the risk of corrosion of the reinforcement.

16. Discuss about the quality of supervision to be followed at a site.

Construction work should be carried out as per the laid down specification. Adherence to specified water-cement ratio controls strength, permeability durability of concrete. Insufficient vibration may result in porous and honey combined concrete, whereas excess vibration may cause segregation.

17. What are the possible decisions that can be made after evaluating the strength of a structure?

a. to permit deterioration to continue
b. to make measures to preserve the structure in its present condition without strengthening
c. to strengthen the construction
d. if deterioration is exceptionally sever, to reconstruct or possibly abandon it.

18. How can we evaluate the strength of existing structure by stress analysis?

This method is to make detailed stress analysis of the structure, as it stands including allowances for loss of section where it has occurred. This is more difficult & expensive. Here also the first stop is to make preliminary analysis by fixed percentage method and if it appears that major repairs will be required, the strength is reevaluated based on detailed stress analysis, considering all contributions to such strength.

19. Define the load test method of evaluating the strength of existing structure.

Load tests may be required by the local building offered, but they should only be performed where computation indicated that there is reasonable margin of safety against collapse, lest the test bring the structure sown. Load test show strengths much greater than computed strengths when performed on actual structures. When performed on actual structures. In repair work every little bit of strength is important.

20. What are the possible decisions after finding a structure to be inadequate?

- if the appearance of the existing condition is objectionable – repair now
- if appearance is not a problem then
- Put the condition under observation to check if it is dormant or progressive.
- if dormant – no repair
- if progressive – check the feasibility & relative economics of permitting deterioration to continue and performing a repair at some later date & of making the repair right away

UNIT-II

2 Marks

1. How can use prevent the effect of freezing and thawing in concrete?

Concrete can be restricted from frost action, damage of the structure by the entrainment of air. This entrainment of air is distributed through the cement paste with spacing between bubbles of no more than about 0.4mm.

2. Write any two tests for assessment of frost damage?

The frost damage can be assessed by several ways:

i) Assessment of loss of weight of a sample of concrete subjected to a certain number of cycles of freezing and thawing is one of the methods
ii) Measuring the change in the ultrasonic pulse velocity or the damage in the change in the dynamic modulus of elasticity of specimen is another method.

3. How does a concrete structure get affected by heat?

Heat may affect cone and as a result of:-

⇒ the removal of evaporable water
⇒ the removal of combined water
⇒ alteration of cement past
⇒ alteration of aggregate
⇒ change of the bond between aggregate and paste

4. How can you control cracks in a structure?

⇒ Use of good coarse aggregates free from clay lumps
⇒ Use of fine aggregate free from silt, mud & organic constituent.
⇒ Use of sound cement.
⇒ Provision of expansion & contraction joint.
⇒ Provide less water-cement ratio.

5. Define aggregate splitting?

This phenomenon occurs most frequently when hard aggregates are used in concrete. The thermal stresses except close to corners are predominantly compressive near to the heated surface. This stress causes the aggregate to split in this direction and the fractures may propagate through the mortar matrix leading to deterioration.

6. What the factor affecting chemical attack on concrete?
   - ⇒ High porosity
   - ⇒ Improper choice of cement type for the conditions of exposure
   - ⇒ Inadequate curing prior to exposure
   - ⇒ Exposure to alternate cycles of wetting and drying

7. Write the methods of corrosion protection?

   - ⇒ Corrosion inhibitors
   - ⇒ corrosion resisting steels
   - ⇒ coatings for steel
   - ⇒ Cathodic protection

8. List out some coating for reinforcement to prevent corrosion?

   - ⇒ Organic coating
   - ⇒ Epoxy coating
   - ⇒ Metallic coating
   - ⇒ Zinc coating

9. Define corner reparation?

This is a very common occurrence and appears to be due to a component of tensile stress causing splitting across a corner. In fire tests, corner separation occurs most often in beams and columns made of Quartz aggregate and only infrequently with light weight aggregates

10. List any four causes of cracks?

    - ⇒ Use of unsound material
    - ⇒ Poor & bad workmanship
    - ⇒ Use of high water-cement ratio
    - ⇒ Freezing & thawing
    - ⇒ Thermal effects

⇒ Shrinkage stresses

11. What are the types of cracks?

i) Class-1: Cracks leading to structural failure
ii) Class-2: Cracks causing corrosion
iii) Class-3: Cracks affecting function
iv) Class-4: Cracks affecting appearance

12. What changes occur, when hot rolled steel is heated to 500^{o}c?

At temp of 500^{o}c-600^{o}c the yield stress is reduced to the order of the working stress and the elastic modulus is reduced by one-third. Bars heated to this temp virtually recover their normal temperature.

13. List out the various types of spalling?

i) General or destructive spalling
ii) Local spalling which is subdivided as
⇒ aggregate splitting
⇒ comer separations
⇒ surface spalling
⇒ Sloughing off
⇒

14. List some faults in construction planning?

- Overloading of members by construction loads
- Loading of partially constructed members
- Differential shrinkage between sections of construction
- Omission of designed movement joints

15. Define corrosion?

The gradual deterioration of concrete by chemically aggressive agent is called “corrosion”

16. Give some examples for corrosion inhibitors?

i) Anodic inhibitors
ii) Cathodic inhibitors
iii) Mixed inhibitors
iv) Dangerous & safe inhibitors

17. Define effective cover?

The cover to reinforcement measured from centre of the main reinforcement up to the surface of concrete in tension is called “Effective cover”

18. Define corrosion inhibitor?

Corrosion inhibitor is an admixture that is used in concrete to prevent the metal embedded in concrete from corroding.

19. What are the operations in quality assurance system?
    - Feed back
    - Auditing
    - Review line
    - Organization

20. List the various components of quality control.

Five components of a quality (control) assurance system are:

- Standards
- Production control
- Compliance control
- Task and responsibilities and
- Guarantees for users

UNIT III

2 Marks

1. What is expansive cement?

A slight change in volume on drying is known as expansion with time will prove to be advantage for grouting purpose. This type of cement which suffers no overall change in volume on drying is known as “Expansive cement”.

2. What is the action of shrink comb in expansive cement?

Shrink comb grout acts like a Portland cement. It (shrinks) sets and hardens; it develops a compressive strength of about 140kg/gm^2 at 7days and 210kg/cm^2 at 28 days.

3. List the various types of polymer concrete.

i) Polymer impregnated concrete (PIC)

ii) Polymer cement concrete (PCC)

iii) Polymer Concrete (PC)

iv) Partially impregnated and surface coat

v) Polymer Concrete.

vi) Polymer impregnated concrete (PIC)

4. Give the various monomers used in polymer concrete.
   - Mehylmethacrylate (MINS)
   - Styretoc
   - Aerylonitrile
   - t-butyle slynene

5. Define polymer concrete.

   Polymer concrete is a aggregate bound a polymer binder instead of Portland cement as in conventional concrete pc is normally use to minimize voids volume in aggregate mars. This can be achieve by properly grading and mixing of a to attain the max density and (mixing) the aggregates to attain (maximum) minimum void volume. The entrapped aggregated are prepacked and vibrated in a mould.

6. What are the uses of Polymer concrete?

   During curing Portland cement form mineral voids. Water can be entrapped in these voids which are freezing can readily attack the concrete. Also alkaline Portland cement is easily attached by chemically aggressive materials which results in rapid determination, there as using polymers can compact chemical attack.

7. What is sulphur infiltrated concrete?

New types of composition have been produced by the recently developed techniques of impregnating porous material like concrete with sulphur. Sulphur impregnation has shown great improvement in strength.

8.What are the applications of sulphur infiltrated concrete?

Sulphur – (impregnated) infiltration can be employed in the precast industries. Sulphur infiltration concrete should found considerable use in industry situation where high corrosion resistant concrete is required. This method cannot be conveniently applied to cast- in place concrete Sulphur impregnation has shown area improvement in strength.

9. What is drying shrinkage?

Concrete made with ordinary Portland cement shirts while setting due to less of water concrete also shrinks continuously for long true. This is known as “drying shrinkage”.

10. What is self stressing cement?

This cement when used in concrete with restrained expansion includes compressive stresses which approximately offset the tensile stresses induced by shrinkage “self Stressing cement”

11. What is polymer impregnated concrete?

PIC is a widely used polymer composition concrete, cured and dried in over or dielectric heating from which the air in the (pipes) open cell is removed by vacuum. Then low density manpower is diffused through a open cell and polymerized by using radiation, application of heat or by chemical initiation.

12.Define polymer partially impregnated concrete.

Polymer partially impregnated or coated in dep(CID) and surface coated (SC) control partially polymer impregnated concrete is used to in the strength of concrete. Partially impregnated concrete is sufficient in situations there the major required surface persistent against chemical and mechanical attacks.

13...How can we manufacture sulphur infiltrated concrete?

Sulphur is heated to bring it into molten condition to which coarse and fine aggregates are poured and mixed together. On cooling, this mixture gave fairly good strength, exhibited acid resistance and also other chemical resistance, but it proved to be either than ordinary cement concrete.

14. What is the difference between ordinary cement and expansive cement?

Ordinary concrete shrinks while setting whereas expansive cement expands while setting

15. What are the uses of gas forming and expansive chemicals

Gas formation and expansive chemicals to produce light weight concrete as well as to cause expansion on application such as grouts for anchor bolts. They are non strinking type. Principal chemicals used are Hydrogen peroxide, metallic aluminium or activated or activated carbon. Sometimes bentonite clays and natural gum are also used.

16) what is the use of corrosion inhibiting chemicals

They resist corrosion of reinforcement .in adverse environment sodium benzonate , calcium lingo sulphonate and sodium nitrate have good results

17) Write the use of antifungus admixtures

These are added to control and inhibit growth of bacteria or fungus in surfaces expressed t moisture. Polyhalogenated phenol, Dieldrin emulsion and copper compounds are some of the chemicals used for this

18) What are use of curing compounds

They are either wax based or resin based. When coated in freshly laid concrete they form a temporary film over the damp surface which stops wter evaporation and allows sufficient moisture retention in concrete for curing

19) What are the uses of sealants

They are used to seal designed joints. They are formulated from synthetic rubbers or polysulphides. The choice of a sealant depends on the location of the joint, its movement capability and the function the sealant is expected to perform.

20)what are the uses of flooring

These are usually toppings based on metallic or non metallic aggregates which are mixed with cement and placed over freshly laid concrete sub floor. These compounds in high viscosity liquid, form mixed with recommended filters at site, are based on resins and polymers such as epoxy, acrylic, polyuretheneor polysulphide.

UNIT IV

2 Marks

1. What is Vacuum concrete?

Only about half of the water added in concrete goes into chemical combination and the remaining water is used to make concrete workable. After laying concrete, water which was making concreting workable is extracted by a special method known as “vacuum method”.

2. What are the equipments used in vacuum concrete?

The equipment essentially consists of:-

i. vacuum pump
ii. water separator and
iii. filtering mat

3.What is Gunite?

Gunite can be defined as mortar conveyed through a hose and pneumatically projected at a high velocity on to a surface.

4. What are the two types of process in Shotcrete?

a. Wet mix process
b. Dry mix process

5. What are the stages in dry mix process in shotcrete?

i. In this process, the concrete is mixed with water as for ordinary concrete before conveying through the delivery pipeline to the nozzle, at which point it is jetted by compressed air, onto the work in the same way as that if mix process.
ii. The wet process has been generally desired in favour of the dry mix process, owing to the greater success of the latter.

6. What is shotcrete?

Shotcrete is a recent development on the similar principle of guniting for achieving greater thickness with small coarse aggregate.

7. What are the preliminary investigations before demolition of a structure?

The demolition contractor should have ample experience of the type of work to be offered;

- Fully comprehensive insurance against all risks must be maintained at all times;
- An experienced supervisor should be continuously in charge of the work;
- The contract price should include all safety precautions included in the relevant building regulations;
- The completion date should be realistic, avoiding and need to take risks to achieve the date.

8. Write about protective clothing given before demolition.

Buildings where chemicals have been stored or where asbestos, lead paint, dust or fumes may be present will require specialized protective clothing, e.g.

9. Give a brief note on shoring and underpinning in demolition.

The demolition contractor has a legal obligation to show technical competence when carrying out the work. When removing sections of the building which could have leave other parts unsafe, adequate temporary supports and shoring etc. must be provided.

10. What are the major factors in selecting a demolition procedure?

Majors factors to be considered in selecting an appropriate technique include:-

- Safety of personnel and public
- Working methods
- Legislation applicable
- Insurance cover

11. Give the categories of demolition techniques.

Demolition techniques may be categorized as:-

- Piecemeal demolition, using hand-held tools or machines, to reduce the height of the building or structure gradually;
- Deliberate controlled collapse, demolition to be completed at ground level.

12. Write short notes on demolition by hand.

Demolition of buildings or structure by hand-held tools such as electric or pneumatic breakers, sometimes as a preliminary to using other methods, should be carried out, where practicable, in the reverse order to the original construction sequence. Lifting appliances may be necessary to hold larger structural members during cutting and for lowering severed structural members and other debris.

13. In what cases demolition by machine can be done?

Simple roof structures supported on wall plates should normally be demolished to the level of wall plates by hand, but if this may involve unsafe working, then demolition totally by machine may be appropriate.

14. Write short notes on balling machine.

Balling machines generally comprise a drag-line type crawler chassis fitted with a lattice crane jib. The demolition ball, with a steel anti-spin device, is suspended from the lifting rope and swung by the drag rope.

15. How are explosives used for demolition of a structure?

If explosives are to be used for demolition, the planning and execution, include pre-weakening, should be under the control of a person competent in these techniques. For large demolition, the competent person is likely to be an experienced explosive engineer; for smaller work, a shot-firer may be sufficient.

16 What is a hydraulic pusher arm?

Articulated, hydraulically-powered pusher-arm machines are normally mounted on a tracked or wheeled chassis, and have a toothed plate or hook for applying for applying a horizontal force to a wall. The machine should stand on a firm level base and apply force by a controlled movement of the pusher arm.

17. What is pre-weakening?

Buildings and structures normally have structural elements designed to carry safely the loading likely to be imposed during their life.

As a preliminary to a deliberate controlled collapse, after loads such as furnishings, plant and machinery have been removed, the demolition contractor may be able to weaken some structural elements and remove those new redundant. This pre-weakening is essentially a planned exercise and must be preceded by an analysis of its possible effects on the structure until it collapses, to ensure that the structural integrity of the building is not jeopardized accidentally. Insufficient information and planning relating to the structure may result in dangerous and unsafe work.

18. What is deliberate collapse?

The deliberate collapse of the whole or part of a building or structure requires particularly high standards of planning, supervisions and execution, and careful consideration of its effect on other parts of the structure or on adjacent buildings or structures. A surrounding clear area and exclusion zone are required to protect both

personnel and property from the fall of the structure itself and debris which may be thrown up by the impact.

19. How can you develop a demolition strategy?

The strategy will need to take into account the method of construction used for the original building and its proximity to other buildings, structures and the general public. These factors, together with location, the cost and availability of tipping and disposal and the desirability and economics of reuse, must be taken into account in the development of an appropriate strategy for the demolition of a structure.

20. What are nibblers?

Nibblers use a rotating action to snap brittle materials such as concrete or masonry. In either case, material should be removed from the top of walls or columns in courses not greater than 600mm in depth, steel reinforcement should be cut separately as necessary.

21. What are the considerations before demolition?

Considerations should be given to:-

- Conducting a site and building survey, with a structural bias;
- The examination of drawings and details of existing construction where available;
- The preparation of details and drawings from site survey activities where no such information is available;
- Establishing previous use of premises, especially with regard to flammable substances or substances hazardous to health or safety;
- Programming the sequence of demolition work;
- The preparation of a Method Statement.

UNIT V

2 Marks

1. What are the techniques required for repairing cracks?
    - Bonding with epoxies
    - Routing and sealing
    - Stiitching
    - Blanketing
    - External stressing
    - Grouting
    - Autogenous healing

2. Define stitching.

The tensile strength of a cracked concrete section can be restored by stitching in a manner similar to sewing cloth.

3. What do you mean by blanketing?

This is the simplest and most common technique for sealing cracks and is applicable for sealing both fine pattern cracks and larger isolated. The cracks should be dormant unless they are opened up enough to put in a substantial paten in which case the repair may be more property termed as “Blanketing”.

4. Define external stressing.

Development of cracking in concrete is due to tensile stress and can be arrested by removing these stresses. Further the cracks can be closed by including a compressive force sufficient to over come the tension a residual compression.

5. Write short notes on Autogenous healing.

The inherent ability of concrete to heal cracks within “autogenous healing”. This is used for sealing dormant cracks such as precast units cracked in handling of cracks developed during the precast pilling sealing of cracks in water hands and sealing of cracks results of temporary conditions.

6. What is overlay?

Overlays may be used to restore a spelling or disintegrated surface or to protect the existing concrete from the attack of aggressive agents. Overlays used for this purpose include concrete or mortar, bituminous compounds etc. Epoxies should be used to bond the overlays to the existing concrete surface

7. Give short note on Jacketing.

Jacketing consists of restoring or increasing the section of an existing member by encasing it in a new concrete. This method is useful for protection of section against further deterioration by providing additional to in member.

8. Give an account on how metal bonding is done on concrete member.

On the tension side of the beam 2to 3mm steel plates are to the existing beam to increase its capacity. The glue or adhesive should compatible with the existing concrete with behavioral characteristics under load addition to providing integrity with parent member.

9. How clamps are used to overcome low member strength?

The distress is due to inadequate stirrups either due to deficiency in the of provision of C- stamps, U-clamp fixed externally along the length of beam to provide adequate these will be protected by covering with rich mortar or concreting as the a later stage.

10. Define grouting.

Grouting can be performed in a similar manner as the injection of an epoxy. However the use of an epoxy is the better solution except where considerations for the resistance of cold weather prevent such use in which case grouting is the comparable alternative.

11. Give a short note on epoxy coatings.

These are organic compound which when activated with suitable hardening agents form strong chemically resistant structures having excellent adhesive properties. They are used as binders or adhesives to bond new concrete patches to existing surfaces or hand together cracked portions. Once hardened, this compound will not melt, flow or bleed. Care should be taken to place the epoxy within the pot life period after mixing.

12. What are protective surface coatings?

During of concrete can be substantially improved by preventive maintenance in the form of weather proofing surface treatments. These treatments are used to seal the concrete surface ad to inhibit the intrusion of moisture or chemicals.

13. List some materials used as protective surface coatings.

Materials used for this purpose include oils such as linseed oils, petroleum etc.

14. Define dry pack.

Dry packing is the hand placement of a very dry mortar and subsequent tamping or ramming of the mortar into place producing an intimate contact between the old and new concrete work.

15. Give a brief account on routing and sealing.

This method involves enlarging the cracks along its exposed surface, filling and finally sealing it with a suitable material. This is the simplest and most common technique for sealing cracks and is applicable for sealing both fine pattern cracks and larger isolated.

16. List any four causes of cracks?

⇒ Use of unsound material
⇒ Poor & bad workmanship
⇒ Use of high water-cement ratio
⇒ Freezing & thawing
⇒ Thermal effects
⇒ Shrinkage stresses

17. What are the types of cracks?

v) Class-1: Cracks leading to structural failure
vi) Class-2: Cracks causing corrosion
vii) Class-3: Cracks affecting function
viii)Class-4: Cracks affecting appearance

18. What is pneumatically applied mortar?

Pneumatically applied mortar is used for the restoration of when the location of deterioration is relatively at shallow depth. It can be used on vertical as well as on horizontal surfaces and is particularly restoring surfaces spalled to corrosion of the reinforcement. Damaged concrete elements also retrofitted using this method. This also has known as gunning or shotcreting techniques.

19. What is caging with steel?

A steel caging is prepared and made to surround the existing masonry so that lateral expansion when it is loaded in compression. The confinement of masonry will steel cage increases its capacity and ductility.

20. Give a brief note on dogs in stitching.

The dogs are thin and long and to cannot take much of compressive force. The dogs must be stiffened and strengthened by encasement in an overlay or some similar means.

21. Give some concrete materials used to overcome weathering action on concrete.

The two concrete repair materials used were (*i*) a flow able concrete with 16 mm aggregate and containing a plasticizer and a shrinkage-compensating additive, to be cast against forms in heights up to 1.5m, and (*ii*) a patching mortar to be applied b rendering, for areas less than .01 m^2.

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Unit I

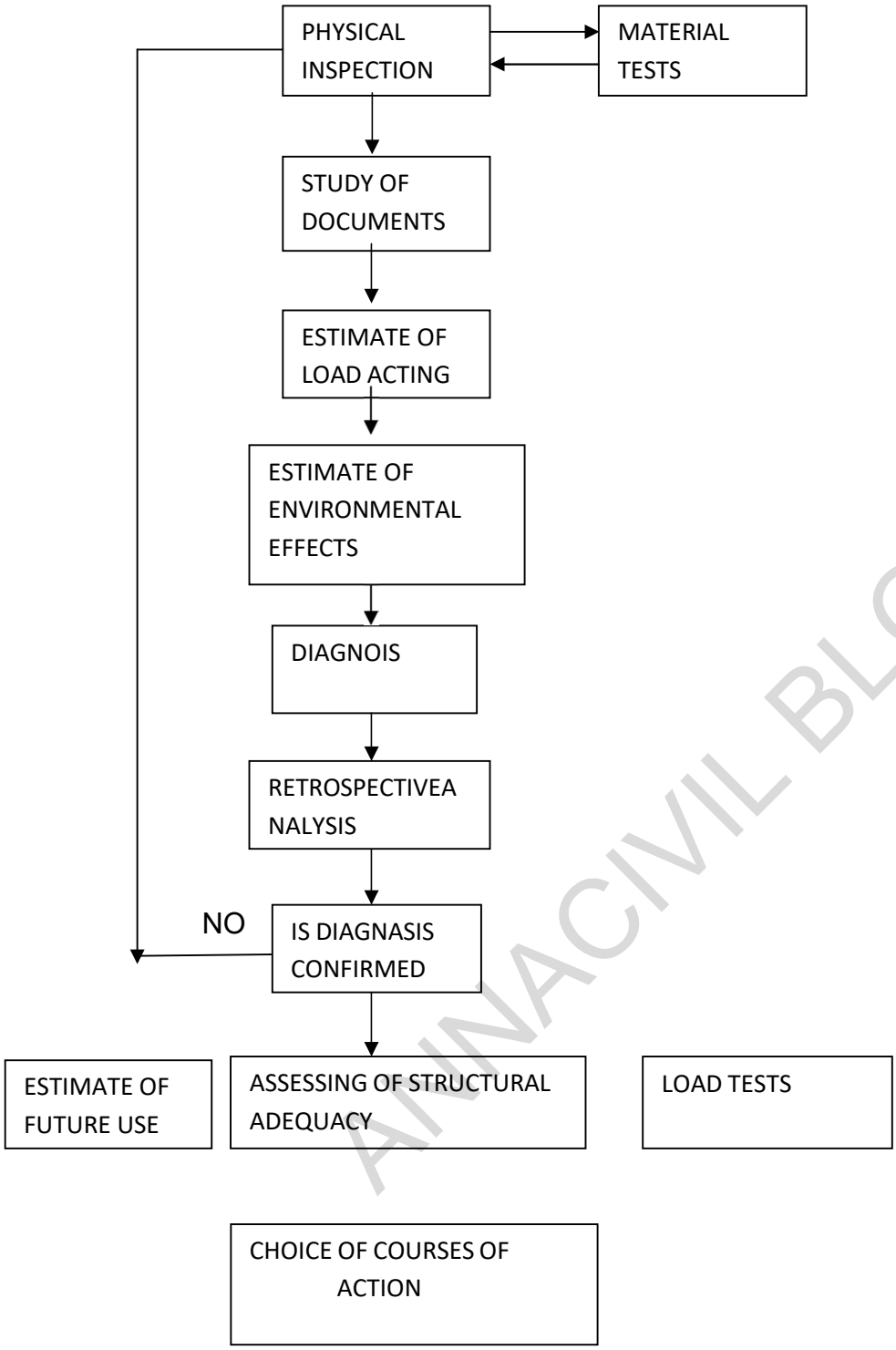
16 marks

1. Describe the steps in the assessment procedure for evaluate damages in a structure.

The following steps may be necessary

i. Physical Inspection of damaged structure.
ii. Preparation and documenting the damages.
iii. Collection of samples and carrying out tests both in situ and in laboratory.
iv. Studying the documents including structural aspects.
v. Estimation of loads acting on the structure
vi. Estimation of environmental effects including soil structure interaction.
vii. Diagnosis
viii. Taking preventive steps not to cause further damage
ix. Retrospective analysis to get the diagnosis confirmed
x. Assessment of structural adequacy
xi. Estimation on future use
xii. Remedial measures necessary to strength and repairing the structure.
xiii. Post repair evaluation through tests
xiv. Load test to study the behavior
xv. Choice of course of action for the restoration of structure.

A simple flow chart incorporating the above points in presented in Figure



2. Explain the various causes for deterioration of concrete structures.

Some of the causes of deterioration of concrete structures are discussed in of the chapters devoted for this purpose. A few details are presented here.

i) Design and construction flaws

Design of concrete structures governs the performance of concrete structures. Well designed and detailed concrete structure will show less deterioration in comparison with poorly designed and detailed concrete, in the similar condition. The beam-column joints are particularly prone to defective concrete, if detailing and placing of reinforcement is not done properly. Inadequate concrete cover may lead to carbonation depth reaching up to the reinforcement, thus, increasing the risk of corrosion of the reinforcement.

ii) Environmental effects

Micro-cracks present in the concrete are the sources of ingress of moistures atmospheric carbon di-oxide into the concrete which attack reinforcement and with various ingredients of concrete. In aggressive environme4nt concrete structure will be severely reduces.

iii) Poor quality material used

Quality of materials, to be used in construction, should be ensured by means various tests as specified in the IS codes. Alkali-aggregate reaction and sulphate attack results in early deterioration. Clayey materials in the fine aggregates weaken the mortar aggregate bond and reduce the strength. Salinity causes corrosion of reinforcing bars as well as deterioration of concrete.

iv) Quality of supervision

Construction work should be carried out as per the laid down specification. Adherence to specified water-cement ratio controls strength, permeability durability of concrete. Insufficient vibration may result in porous and honey combined concrete, whereas excess vibration may cause segregation.

v) Deterioration due to corrosion

- Spelling of concrete cover
- Cracks parallel to the reinforcement
- Spelling at edges
- Swelling of concrete
- Dislocation
- Internal cracking and reduction in area of steel reinforcement.

3. Describe in detail about the prevention aspect of maintenance.

Of the two considerations – prevention & repair, prevention is more important.

During construction the defects that may seem minor, will have serious consequences. The design engineer is responsible for the selection of proper materials suitable for the exposure conditions of site, detailing of the structure in a manner to prevent serious deterioration atleast for the assumed service life and through the inspection staff must consist on proper construction.

These 3 points – proper materials, proper details, and proper construction require knowledge of what is improper at a site or construction; about the various ways of deterioration and about their causes. But these are some general considerations that should be taken into account for both the construction of new concrete structures and the repair of deteriorated structures. They are as follows

i) Match the materials to the environment:

Durability becomes an issue when a material's resistance to deterioration is less than that required to withstand the aggressiveness of the environment in which it is to function. For e.g.:- Steel will not corrode in a dry and salt free environment, but it will do so in the presence of moisture and chloride ions.

To ensure the choice of an appropriate material, the environmental conditions to which the material will be exposed must be known so that its behavior under these conditions can be predicted and addressed in the design. When a designer contemplates using a new material, problems may arise if there has not been sufficient experience with the material to adequately understand it's behavior or to allow for the development of standards.

In the absence of standards, several factors should be critically evaluated, among them the relevance of the test data provided in product literature, and the limitations & requirements associated with the environmental conditions of the project.

The following factors should be considered by the designer at the construction site.

⇒ Minimum and maximum temperatures
⇒ temperature cycles
⇒ exposure to ultra violet radiation
⇒ amount of moisture
⇒ wet/dry cycles
⇒ presence of aggressive chemicals

iii) Combine only materials with similar properties:

Concrete is a solidified mixture of diverse materials. When these materials are incompatible with one another, the concrete cracks & spalls, resulting in unsightly surfaces and the need of expensive rehabilitation work. Materials are considered to be incompatible when the differences in their physical or chemical properties exact a state of instability.

For e.g.:- Galvanic corrosion is promoted when 2 metals with different electrochemical properties are combined in a building assembly.

The use of materials with different thermal coefficients or different modulli of elasticity should also be avoided. Since they expand and contract at different rates, and their deformation characterizes are significantly different. In both instances, the incompatibility of the selected materials will lead to deterioration of the concrete. When the load perpendicular to the bond line, the difference in modulus does not cause. Problems, however, when it is parallel to the bond line, deformation of the material with the lower modulus transfers load to the material with the higher modulus, which may then fracture.

iii) Assess the limitations of a particular material in its functional context.

The selection of materials, particularly those used in repairs, must based on knowledge of their functions & of the environment in which the materials have to function. Their physical & chemical properties as well as their limitations with respect to installation & performance must also be considered. In particular, the designer should anticipate the degree of abrasion or wear to which a surface will be subjected. For eg:- Parking garages should be designed to resist more abrasion by using special cast concrete and on applied polymeric coating impregnated with an abrasion – resistant material such as corundum.

In choosing a material the designer should be aware not only of the properties that seem to address the intended function but also the auxiliary properties that did not constitute the basis for selecting the material. For eg:- Air entrainment is used to provide durability with respect to freeze & thaw cycles but it also enhances workability.

iv) Protect materials from general deterioration:

Most concrete deterioration can be attributed to water penetration. Source concrete absorbs moisture until it become, saturated, prevent entry water from collecting on surfaces is of prime importance. Moisture fosters deterioration not only become it carries dissolved chemicals that can react with steel, time, and other components in the concrete, it also plays a major role in concrete deterioration through freeze) thaw cycles. By providing sufficient slopes and effective drainages, it is possible to prevent water from ponding & thus being absorbed. Concrete design should accentuate water shedding characteristics for vertical elements. For eg:- proper window shads prevent the wall from wetting. Sealing the surface with a penetrating concrete sealing & the use of 50 mm thick reinforcement corer to protect steel are other means of protection.

v)Design level Factors:

Concrete structures are an assembly of operating systems that experience temperature, air pressure and vapour pressure, gradients. Seasonal and diurnal fluctuations on outdoor conditions provide variability and direction of the gradients. These operating conditions can accelerate premature failure of the components in a repair. The relative severity of these factors will vary depending on the use and location of the structure; and the types of repair material used and so on. Predicting these fluctuations and accommodating them at a design stage is important.

Allow for change in use in design:

During the service life of a structure, its environment and occupancy may change. As a result, the structure will have to withstand stresses different from those for which it was originally intended.

For e.g.:- Addition of roof garden to parking lot requires additional protection against ponding of water on the roof of parking lot.

4. Describe in detail about the repair aspect of maintenance.

Even though designers allow a large margin of safety in their designs, once deterioration reaches a critical limit, immediate repair is needed to restore the level of performance to its intended level of service. In fact if the rehabilitation work is not carried out in time, the structure may not be repairable to the required level of service. The execution of such a repair is an exacting, technical matter involving 5 basic steps.

1. finding the deterioration
2. determining the cause
3. evaluating the strength of existing building or structure
4. evaluating the need of repair
5. Selecting & implementing a repair procedure.

i).Finding the deterioration

Before the repair can be effected, there must be a realization that something is wrong, and the realization must come before it is too late to; make a repair, ie before the structure has collapsed

For eg:- timbers and timber piling can be damaged by insects or marine organisms, virtually to the point of collapse, with out exhibiting any external evidence which would be apparent except to a trained observed. Even a common defect like corrosion of steel can be difficult to detect because if occurs, principally, in the most inaccessible parts of the structure. The reason is simple. The accessible parts are painted, but the inaccessible parts often are neglected.

The point to be made is that is that the engineer charged or interested in maintenance must be trained, technically, in where to look, how to look & what to look for, before he can even be expected & realize that there is trouble knowing all these requires a knowledge of various kinds & causes of deterioration & before checking the engineer must know all these.

ii) Determine the Cause

To select the repair step, the cause has to be identified. Incase of concrete the specific cause might not be known due to several agents acting. What can be done is to eliminate possibilities and design repair procedures for any of the remaining few. In such cases the cost will go higher. But it should also be noted that the failure to understand the cause of a defect fan lead to the selection of a repair procedure which would be harmful, rather than helpful. There are no set rules for determining the cause but with experience you can determine. For eg:- (racks in walls due the foundation settlements run diagonally

(Cracks due to corrosion of reinforcement run straight & parallel at uniform intervals & show evidences of rust, staining

A few tips are as follows

e) Inspect & observe the structure
f) Observe in bad & good weather
g) Compare with other constructions on the area or elsewhere & be patient
h) Study the problem & allow enough time to do the job

iii) Evaluate the strength of the Existing structure

This should be done to know whether it is safe to continue using the structure or limit it to a less severe extend of usage if the structure has not completely deteriorated the adequacy of determination of strength becomes important for that the following methods can be used

a) Fixed percentage method

It is to assume that all members which have lost less than some predetermined % of their strength are still adequate and that all members which have lost more than the strength are inadequate. It is usually from 15% onwards higher values are applicable for piling % stiffness bearing plates etc

b) Analysis of the Actual stress condition:

This method is to make detailed stress analysis of the structure, as it stands including allowances for loss of section where it has occurred. This is more difficult & expensive. Here also the first stop is to make preliminary analysis by fixed percentage method and if it appears that major repairs will be required, the strength is reevaluated based on detailed stress analysis, considering all contributions to such strength.

c) Load test

Third step is load test. Load tests may be required by the local building offered, but they should only be performed where computation indicated that there is reasonable margin of safety against collapse, lest the test bring the

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structure sown. Load test show strengths much greater than computed strengths when performed on actual structures. When performed on actual structures. In repair work every little bit of strength is important.

Accordingly the use of load test is recommended but with a full & clear understanding of their limitations and range of applicability.

iv) Evaluate the need of repair

When the cause of the deterioration has been determined and the strength of the existing structure has been checked, a decision must be made whether

a. to permit deterioration to continue
b. to make measures to preserve the structure in its present condition without strengthening
c. to strengthen the construction
d. if deterioration is exceptionally sever, to reconstruct or possibly abandon it.

These decisions are based on

a) safety
b) economy &
c) appearance subject to various principles different decision may be appropriate for different elements of same structure

Case – a] Analysis show that structure still has adequate strength

- if the appearance of the existing condition is objectionable – repair now
- if appearance is not a problem then
- Put the condition under observation to check if it is dormant or progressive.
- if dormant – no repair

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- if progressive – check the feasibility & relative economics of permitting deterioration to continue and performing a repair at some later date & of making the repair right away

Case – b] Analysis shows that the strength of the structure currently is or sowty will be in adequate

- Either repair it or
- Rebuild it or
- Abandon it, partly or completely or
- consider a change of use

v) Select & implement a Repair procedure:

- Select the least expensive that can suit the job

Steps of Repair

- Consider total cost
- Do repair job in time
- If defects are few & isolated repair on an individual basis. Otherwise do in generalized manner
- Ensure the repair prevents further development of defects
- Incase of lost strength, repairs should restore the strength
- If appearance is a problem, the number of applicable types of repairs become limited & the repairs must be covered
- Repair works should not interface with facilities of the structure
- Take care in addition of section to a member and in restributing live loads and other live load moments. After selecting a suitable method of repairs, and after considering all the ramifications of its application, the last step is to prepare plans & specification and proceed with the work.

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5. Explain in detail about the permeability of concrete.

- Since concrete is a permeable and porous nature, the liquid and gases can move inside the concrete and is called “Permeability ie., the liquids and gases that can move in the concrete is determined by its permeability”.
- Thus the permeability is much affected by the nature of the porous, both their size and he extent in which they are inter-connected.

Characteristic study of permeability:

- The hardened cement paste consists of gel porous to the extent of about 28% but the gel porous are so small that water can pass-through under normal conditions. The permeability of gel is 1/100 of that of paste. There fore the gel pores don’t contribute to he permeability and that of capillary cavities depends on the nation.

Causes:

- The higher permeability of concert f structure is due to,
- Formation of micro-cracks due to long term drying shrinkage.
- Rupture of internal face, bond between agg and past.
- Due to volume change caused in the concrete on account of various minor reasons.
- Existence of entrapped air due to insufficient compaction.

Control of permeability:

- The use of azzolanic materials in optimum proportions skill reduce permeability. This is due to the conversion of eql, hydroxide, otherwise soluble and leachable into cementations compound.
- Though air entrainment makes the concrete pours, klben used up to abut 8% which makes cone more impervious contrary to general relief.

Effects of permeability on concrete material reinforcement steel:

- The permeability of moisture or gas is important in relation with the protection afforded to embedded relief or steel.
- The reaction of water with the steel bars so that the bars way be corroded (and rusting of steel occurs).

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Effects of permeability on concrete:

- Permeability characteristics of concrete is of greater bearing on its durability.
- The penetration of aggressive liquid or gas in concrete depend upon the extent of the degree of permeability of concrete.
- The permeability characteristics of concrete (hardened) consists of gel pours and capillary cavities. The gels are porus to the extent of about 28% but the gel porous are so small that hardly any water can pass though under narrow conditions. The permeability of gel is 1/100 of that of paste. Therefore he gel porous don't contribute to the permeability of concrete where a the capillary cavities depends on the W/c ratio. This is one of the main factors contributing or influencing permeability of concrete.

Unit II

16 Marks

1. Explain in detail about quality assurance.

Quality assurance scheme is a management system which increases confident that a material product of service will confirm to specify requirements.

Functions of quality assurance:

It outlines the commitment policies, designated responsibilities and requirements of the owner. These are the implemented through quality assurance programme to provide a meaning of controlling to predetermined requirements. These activities, which influence quality.

In the manufacture of virtually every complex produce a quality assurance scheme of one type or another is used.

Factors influencing Quality Assurance:

Depending upon the value of the product and methods used in the circumference such scheme may themselves become extremely complex. So that it cannot in all cases guarantee all the functional requirements illustrations.

The need of quality assurance:

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In the construction of concrete structure, quality assurance in necessary to give good performance and appearance through out its intended life is attained.

It is useful for promoting the ------schemes by engineers. The designer depends upon this for reputation and professional failure to appearance.

Cases may also include:

Misinterpretation of design and drawings or other specifications. Lack of effective communication with suppliers and co-contractor. Inefficient coordination of sub-contracted work. In adequate on site supervision, poor workmanship due to inadequate skills and experience of the labor force.

Purpose of structural failure:

- Communication and organization in construction industry.
- Inspection of construction by the structural engineer.
- General Quality of design.
- Design details and shop drawings.
- Timely dissemination of technical data.

Development and operation of quality assurance system:

The basic mechanism available for both the development and operation of a quality management system.

Organization: Which requires clear definition of responsibilities and relationship for the total construction project.

Auditing: Which requires the ability to determinate that the tasks defined under responsibilities are continuously being executed according to stated methods.

Review line: Which requires continuous checks on process methods and action procedures adopted if stated requirements are not being met.

Feed back: Which requires deduction in measurable terms of causes of errors that generate defects, in order that processes can be changed so as to reduce non conformance and shown the benefit of such change to be demonstrated.

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Design Procedure:

- Recognition that a quality management system cannot compensate for conceptional error or inadequate specifications. The system merely aims for consistent application of procedures to meet the specification. A poor input could procedure a consistently satisfactory, but quality control result.
- Concern at the cost of introducing and maintain a management system without reassurance of consequential benefits.
- Doubts on the effectiveness of a quality management system t design. In particular doubts that quality assurance procedures for manufacturing process may not be appropriate for design service.

2. Describe the various components of quality control.

Five components of a quality (control) assurance system are:

- Standards
- Production control
- Compliance control
- Task and responsibilities and
- Guarantees for users

Standards or specifications:

- Standards or specifications are used to define the important enteria, methods of assessment or testing and levels of acceptance to satisfy the tested (component) requirement.
- They should of, if possible be expressed in performance terms according to “Newman” however forms that “proposals” or “performances type” specifications for concrete work of significance are totally unrealistic and thereby reflect the unawareness that they can produce inferior results despite apparently acceptable performance or appearance unless each step will be covered by the next step is inspected as the proceed.
- In connecting the specifications, notes that the only good specification t that which requires only these things that need to be done make concrete suitable for its purpose.
- A good specification contains no requirements that can be ignored of lighted and is one that omits by requirements that must be met.
- It is not possible to write specification but possible to do so.

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Production or internal control procedure:

- Production or internal control procedure requires to be done by each of the parties to confirm that its own personal and operations are confirming to its own quality control standards.
- Internal control is generally under taken on a regular test by the person responsible for the particular operation.

Compliance or acceptance control procedure:

- Compliance or acceptance control procedure are required to be applied to the material and to the structural members at the end of each constructional operation.
- It is often the duty of the person who is to the continue work on the resultant product to check such compliance it may be done at critical stages by a independent authorized body during regularity inspections.
- Compliance or acceptance control may also be undertaken by the design engineer and in this case, a problem of costs for more regular inspection of work than its usual may arise.
- Unfortunately no universal scheme for inspection for all such stages of connection ca hope to cover the many variations observed on site.
- Probably the most connecting evidence of will conducted inspections lies in the documentation which forms the inspection (theories) records.

Inspection records:

- The inspection records should include written check line for items inspected, inspection results, acceptance criteria, non-compliance remarks, inspectors signature and company affiliations.

Tasks and responsibilities:

- Definitions for task, functions, and responsibilities of each party and for each activity need to be established.
- Tasks and functions should include the total scope as well as any limitations of both technical and organizational rules.

Guide lines for users:

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- Guarantees for the users including inabilities for faults, should be fully covered by the contract and
- In some cases, by the building (contract) control system or rather less desirably by the law of torl.

3. Discuss in detail about the thermal properties of concrete.

The three important thermal properties of concrete are,

- Thermal conductivity of concrete.
- Co-efficient of thermal expansion and
- Fire resistance.

Thermal character of concrete:

- The process of hydration of cements materials releases heat which raises the temperature of concrete. This heat mush eventually be lost to the atmosphere and the cone temperature has to reach equilibrium with a long term atmosphere conditions.
- The atmospheric gradients may occur or develop in the concrete as the internal temperature is raised above the surface temperature of the concrete member. This surface temperature is dependent on the material in contract. The resulting temperature will produce tensions in the surface and may be stiffness to cause cracking.
- The second effect operates as the mean temperature of the member am remain move that of connecting members and the subsequent cooling will induce tensions.

Thermal conductivity of concrete:

- Thermal conductivity of heat is the ability o the materials to conduct heat.
- Heat is defined as the ratio of the ratio of the flow of heat to the atmospheric gradient and this thermal conductivity is measured in Jules per second per square meter.
- The thermal conductivity of heat depend the composition with respect to the type of aggregate amount of ass and moisture continent.
- When the concrete is saturated the conductivity ranges from 1.4 and 3.6 m/sec.
- The thermal conductivity various more rapidly in light wt one than heavy or normal wt concrete.

Thermal expansion of concrete:

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- Coefficient of thermal expansion of cone is an important property which affects the stability and durability at different temperature conditions.
- As the con is made up of two phases material namely paste and agg paste which has dissimilar thermal con efficient but the coefficient of cone is a resultant of these two phases.
- In general form the coefficient of thermal expansion of cone is a function of the quantity of aggregate in the mix and the coefficient of thermal expansion of agg by itself.

Fire resistance:

- Even cone is not a refractory material but a good combustible and has a good fire resisting properties.
- Fire resistance of concrete is determined by three factors.
- The capacity of cone itself to with stand heat.
- The subsequent action of water without losing strength unduly without cracking or spelling.
- And the conductivity of the concrete to heat and coefficient of thermal expansion of concrete.

Action of fire on (concrete) steel:

- The fire introduces high temperature gradients and as a result of it, the surface layers extent to separate and spall off from the cooler interior.
- The heating of reinforcement aggravate the expansion both laterally and longitudinally of the reinforcement base resulting in loss of bond and loss of strength of reinforcement.

Fire resistance on concrete:

- Fire on cone building damages the cone as well as steel reinforcement, causing disintegration of the cone and buckling of steel.
- The temperature gradient is extreme 30 to 40^{o}c on the outer face and above 800^{o}C on the interface (near the source of fire).
- In the initial stage (half an hour) as the heat inside builds up, some aggregate. Expand suddenly, spelling the adjacent concrete. Moisture in concrete rapidly changes to steam, causing localized bursting of small pieces of cone. Extreme heat near the sources of fire causes spalling rapidly expanding cone surfaces.

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- In the next 30 minutes a temperature inside reaches 400^{o}C, the cement matrix converts to QuickTime causing disintegration of concrete. The reinforcing steel loses the ensile capacity at such temperature. Deflection of beams and slab increases beyond this limit.
- Beyond one hour of fire, as the concrete disintegrates, the exposed steel expands, more rapidly than the surrounding concrete causing buckling, loss of bond to adjacent conc.
- The thermal conductivity of any concrete can be calculated from

  K = Km (2m-m2)+km k2 (1-m)2 / K2M +Km (1-m)

  K = conductivity of aggregate

  Km = conductivity of motor

Thermal effects on concrete:

- Excess water in concrete evaporates due to heat and setting of cone occurs. The loss of moisture to evaporation causes the cement paste matrix to contract, leading to shrinkage stress and shrine erecting.
- A 6m long slab may shrink 3mm to 5mm along its length called "drying shrinkage".
- If the slab is supported at both its ends stress build up due to shrinkage drying may exceed the tensile strength of concrete, resulting in a 3mm to 5mm wide crack.
- However if the cone is properly reinforced at regular intervals, the shrinkage stress are distributed along the length of slab, resulting uniformly spaced fine cracks.

4. Elaborately explain about the effect of temperature on concrete.

- Similar to other materials, cone expands with increase in temperature and contract with decrease in temperature. The range of variation in temperature varies from localities to localities, season to season and day to day.
- The objectionable cracks may occur in cone due to contraction combined with the effect of shrinkage.
- Occasionally large and harmful stress may develop due to deformation because temperature changes.
- The coefficient of thermal expansion of contraction depends on the type and quantity of cement, aggregate, relative humidity and sizes of section.

Concrete at high temperature:

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- In some industrial application such as aluminum plants and brick works the cone may be occasionally or frequently subjected to temperatures. These temperatures are likely to be applied linearly.
- Generally with and rather a long period.
- Similarly jet aircraft and vertical take aircraft may subject the payment to very high temperature.
- Heat may affect concrete and as a result of,
- The removal of evaporable water.
- The removal of combined water.
- Alteration of cement paste.
- Disruption (of beam) from disparity of expansion and resulting thermal stresses.
- Alteration of aggregate.
- Change of the bond bet aggregate and paste.
- Other effects on cone due to temperature.
- Cycles of temperature can have a progressive effect on the reduction of strength even longer curing did not improve the loss.
- Tensile strength of cone is more effect by heat than its com strength.
- During rapid rise and fall of temperature the response of cone is affected by the interaction of thermal expansion, drying thermal incompatibility and enhanced every at high temperature.
- If the heating is sufficiently rapid, high stresses can be included; hence failure and instability may result.

Effects of steel at high temperature:

- The influence of temperature on steel appears as a change in yield stress, ultimate strength and modules of elasticity.
- The changes depend on the type of steel and are greater in cold-weathered steel.
- The strength of hot-rolled steel bars are not reduced if the temperature does not reach to 300^{o}C. But at temperature of 500-600^{o}C the yield stress is reduced to the order of the working stress and the elastic modules is reduced by one-third.
- Bars heated to this temperature virtually recover their normal temperature.
- Bars heated to 800^{o}C have a lower residual strength after cooling to room temperature.
- Pre-stressing wire and stand starts to lose strength at 150^{o}C and may have only 50% of its room temperature strength when heated to about 400^{o}C.
- The below fig shows the summery of,

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Behavior of fire:

- Failure in a fire occurs either through the spread of fire from the compartment or through structural failure of a member or assembly of members.
- Structural failure of a member most frequently occurs when the temperature of the steel reduces the yield stress to the working stress.

The length of time of this fire occurs depend upon the severity of fire, the thermal conductivity of the protecting concrete and weather spalling of the protection covers.

5. Explain the various corrosion protection methods.

Methods of corrosion protection:

- Corrosion inhibitors.
- Corrosion resisting steels.
- Coatings for steel and,
- Cathode protection.
- Corrosion inhibitors.
- Corrosion inhibitor is an admixture that is used in concrete to prevent the metal embedded in cone from corroding.

Types of inhibitors:

- Anodic inhibitors: (alkalis, phosphates, chromates, nitrates, benzoates).
- Anodic inhibitors function by decreasing the reaction at the anode.
- They may react with the existent corrosion product to form an extremely insoluble adherent coating on the metal surface.
- Organic inhibitors replace water at site on the inner plate, thus decrease corrosion.

Cathode inhibitors (calcium carbonate):

- Aluminium oxide and magnesium oxide.
- Cathode inhibitors act to stifle the cathode reaction.
- They are generally less effective since they do not form films on the anode.

Mixed inhibitors:

- A mixed inhibitors may affect both and cathode processes.

Dangerous and safe inhibitors:

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- A safe inhibitor is defined as one which reduces the total corrosion with out in erecting area; while dangerous inhibitors produce increased rates can be due to the lack of sufficient inhibitors to prevent complete protection or the presence of crevices into which the inhibitor does not rapidly diffuse.
- Anodic inhibitors are generally dangerous except sodium benzoate.
- Cathode inhibitors are generally safe, but since sulphate is an exception.

Classification of inhibitors:

- Somewhat a different classification based on the actions of such as,
- Barrier layer formation.
- Neutralization and,
- Savaging.
- These represent processes by way of which the passivation is achieved it is interested to note that the barrier layer formation is generally best achieved by simply completely coating steel with a well curved low water cement paste which needs to extra admixture at all.

Corrosion resisting steel:

- In mid steel, the corrosion is not sufficiently or corrosion is not sufficiently or significantly affected by composing, grade or level or stresses. Hence substitute steels for corrosion resistance will have a significantly different compaction.
- Based on some atmosphere, corrosion weathering, steels of correct type were tested in concrete. They did not perform well in most content containing chloride it is observed that the weathering steel corrode in similar concrete to those can corrosion at high yield strength steel. Although the total amount of corrosion less than would occur on high yield steel under similar conditions, deep localized pitting developed, which could be more structurally weakened.
- Stainless steel pipe has been used special applications especially as flames in precast members, but generally not expect use as a substitute for wild steel any case, stainless steel should not concrete involving under corrosion resistant.
- Stainless steels contains relatively lower content of chloride levels, there was a based in a delayed time to cracking relative to that for high strength steels, but this was offset by irregular pitting corrosion. Very high corrosion resistance was shown by austenitic stainless steels in all the environments in which they were tested, but the observation of some very high pitting in the preserve of chlorides lead to the warming the corrosion susceptibility was not evaluated in the test programme.

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Coating of steel:

- Coatings are sometimes considered as for mild steel is to be embedded in concrete exposed to advise corrosive condition.
- There are both benefits and disadvantages to their use and any benefit can only be optimized by carefully considering the specific job. The more obvious of those considerations are,
- Do the expected service life and structure exposure warrant coating of the steel.
- If coating is desirable, is a field of job read or may the coating be applied prior to fabrications of the reinforcing, for the structure.
- Do transportation and subsequent lubrication pose a significant danger to the coating.
- In view of the exposure conditions, is the choice of coating dictated by these condition rather than adoption of other measures.

Groups of coating:

Organic coating:

- Organic coatings include coal tar enamel epoxy, asphalt, chlorinated rubber, vinyl, phenolic, neoprene and methane.
- Out of these, epoxy group is appeared to have the best potential for use.

Epoxy coatings:

- Epoxy coatings provided excellent corrosion protection of prestressing steel.
- The epoxies are wear resistance.
- Epoxies are used to protect the steel reinforcing bars embedded in concrete of bridge. Decks from rapid corrosion. This corrosion is caused by the chlorides ions from the most commonly applied deicing salts, sodium chloride and calcium chloride.
- Results obtained from epoxy and polyvinyl chloride coatings, if properly applied could be expected to adequately protect steel reinforcing bass from corrosion.
- However only the epoxy coated bars had acceptable bond and creep characteristics when embedded in concrete.
- The power epoxy coatings overall performed better than the liquid epoxies and four epoxy coatings were identified as promoting materials to be used on reinforcing steel bass embedded in concrete of experienced bridges.

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- The epoxy coat acts (as) to isolate the steel bass from contact with oxygen, moisture and chloride. However, at damaged point on the cost corrosion may commence such damage exists on the bar coupled to uncoated steel the performance of such bar is still considered to be satisfactory, but not as good as when all bar is coated.
- The slab specimen showed little differ on crack width, spacing, deflections or ultimate strength for coated and un-coat bar. The slab containing epoxy-coated bar generally failed to flexure rather than in bond at approximately 4% lower loads than with uncoated bar.
- The beam specimen in which (flexural type loads here applied to the reinforcing bar splitting occurred along the reinforcing bass, but failure was primarily by either pull out or yielding of the embedded steel.
- Organic coatings other than epoxy have occasionally been used. In Germany PVC has been used on welded wire fabric.

Metallic coating:

- Metallic coatings re capable of providing protections to the black steel on one of two ways.
- Metals with a more negative corrosion potential than steel such as zinc, and cadmium, provide sacrificial protection to the steel embedded in concrete, although the development of passivating products on the coating is of significance in the longer time steels and alloys with a less negative corrosion potential (more able) than the bar steel, such as nickel and stainless steel, protect the reinforcement only as long as the coating is un broken since the bar steel is anodic to the coating. The steel is protected by such metals simply by encapsulation.
- Metallic coating is limited to galvanizing material.
- Coating of metals under mass exposure conditions, as in the presence of conditions zinc coating does not always provide increased protection.
- Cadmium suffers from a cost disadvantage when compared to zinc and the derivatives are slightly toxic.

Other coatings:

- Zinc coating.
- Zinc coating is used where longer life protection is desired than can be provide by usual methods of coating it is not a permanent protection, however and in moist, tropical climates the galvanized coating itself is usually protected with a good-

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quality paint. Galvanizing is also useful for subaqueous exposure, where it gives fairly good protection.

- For structural work, it is customary to specify zinc coating by the hot-dip process (galvanizing), because the resulting coating is thicker than that applied by there processes such as the radioing, electroplating or spraying.

Cathodic protection:

- Corrosion in equals environments or in damp soil is primarily electro chemical in nature and is due is a current passing from anodic areas of the metal into solution and returning to the metal at cathode areas. This type of corrosion can be prevented by impressing a countercurrent on the metal in a sufficient amount to neutralize the aggressive electric currents.
- Cathode protection, which consists of the electrical connections of the soon finial anode to the structure to be protected, serves this function by neutralizing the corroding current and forming layers of insoluble reaction products on the new cathode areas.
- In structural applications, cathode application of buried steel (pipe or piling) for protection of the submerged portions of mass structure such as piling and bracing for protecting lock and gates, for the interior of water tanks and for the exterior of burried tanks.

Cathode protection however will not prevent corrosion of structure unless the metal to be protected is sorrows by an electrolyte such a swatter or damp soil and is ineffective in protecting structural elements above the water line or in very dry soil in cathode protection, the effects of the induced currents on adjacent structures may be damaged unless they are adequately bonded to the new system or other means of protections are provided.

Unit III

16 Marks

1. Explain in detail about expansive cement.

Concrete made with ordinary Portland cement shirts while setting due to less of water concrete also shrinks continuously for long true. This is known as “drying shrinkage”

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Cement used for grouting anchor bolts or grouting machine foundations or the cement is used for grouting the prestressed concrete ducts, if it shrinks, the purpose for which the grout is used will be some extent defeated. This has been a reason for such type of cement which will shrinks while hardening and there affect

As a matter of fact, a slight change in volume on drying is known as expansion with time will prove to be advantage for grouting purpose. This type of cement which suffers no overall change in volume on drying is known as “Expansive cement”

Cement of this type has been developed by using expanding agent.

This type of cement is manufactured by adding sulpho-aluminates clinker with 100 parts of Portland cement and is parts of stabilizer.

Types of expansion cement

One types of expansive cements is known as “Shrinkage compensating cement”

This cement when used in concrete with restrained expansion includes compressive stresses which approximately offset the tensile stresses induced by shrinkage “self Stressing cement”. This cement is used in concrete is used in concrete induces significant comp stresses after the drying shrinkage was occurred. The induced comp stresses only compensate the shrinkage but also give sort of prestressing effect in the tensile zone of a flexural member mixing a expansive cement

Normally graded 10mm size mixed with balanced quantity of special binding “Shrink komb” is mixed in a mechanical mixer, has the capacity 200 /140can used to mix 4 bags of grout.

For proper batching of water 10 and cans and a 500c.c measure should used. To obtain maximum advantage the quantity of mixing water should minimum. Mixing should be done for minimum 3 minutes to obtain a good grout of uniform consistency. Depending upon the size of the opening, a small grout can be is used provided it is thoroughly compacted.

<u>Placing and compaction</u>

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The grout should be poured through holes in the base plate up to 10 to 20 mm below the surface, property spread compacted by rodding and vibration.

Curing

The grout should not dry out where external restraint is provided in the form of formwork, the top opening and all stray openings should be covered with wet sack at least for 7 days.

Properties

Shrink komb grout acts like a Portland cement

It (shrinks) sets and hardens; it develops a compressive strength of about 140kg/gm2 at 7days and 210kg/cm2 at 28 days.

2. Briefly explain about polymer concrete and its types.

Continuous research by concrete technologists to understand, improve and develop the properties of concrete has resulted in a new type of concrete, known as “Polymer Concrete”

The increase of the strength of the concrete is achieved by reducing are voids, water voids are by applying vibrations, pressure application spinning etc.

Types of Polymer Concrete

i) Polymer impregnated concrete (PIC)

ii) Polymer cement concrete (PCC)

iii) Polymer Concrete (PC)

iv) Partially impregnated and surface coat

v) Polymer Concrete.

vi) Polymer impregnated concrete (PIC)

Polymer impregnated concrete (PIC)

PIC is a widely used polymer composition concrete, cured and dried in over or dielectric heating from which the air in the (pipes) open cell is removed by vacuum. Then a low

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density manpower is diffused through a open cell and polymerized by using radiation, application of heat or by chemical initiation.

Types of manomers used are:

Mehylmethacrylate (MINS)

Styretoc

Aerylonitrile

t-butyle slynene

Otherthromoplastic monover

The amount of manomer that are loaded into a core specimen is limited by the amount of water and air that has occupied the total void space.

It is necessary be know the concentration of water and air void in the system to determine the rate of monomer penetration.

To obtain the maximum manomer loading in concrete, by the removal of water and air(void) from the cone by vacuum or thermal drying.

The elimination of entrapped air towards the center of the specimen during soaking which will otherwise prevent total or max manomer loading.

The application of pressure is another technique to reduce manomer loading time.

Polymer cement concrete (PCC)

Polymer cement concrete is made by mixing cement, aggregates, water &monomer

The manomers that are used pcc are

Polymer – styrene

Epoxy – Stryence

Futrans

Vinylidene Chloride

The monomers mixed pcc are used distillation units for water desalination plants. However it is reported that on epoxy resin produced a concrete the showed same superior characterizes ordinary concrete.

Polymer Concrete

Polymer concrete is a aggregate bound a polymer binder instead of Portland cement as in conventional concrete pc is normally use to minimize voids volume in aggregate mars. This can be achieve by properly grading and mixing of a to attain the max density

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and (mixing) the aggregates to attain (maximum) minimum void volume. The entrapped aggregated are prepacked and vibrated in a mould.

Manomer is the diffused up through the aggregates and polymerization initialized by radiation or chemical means.

A silence coupling agent is added to the manomer to improve the bond strength between the polymer resins are used then no polymerization is required

Uses of PC

During curing Portland cement form mineral voids. Water can be entrapped in these voids which are freezing can readily attack the concrete. Also alkaline Portland cement is easily attached by chemically aggressive materials which results in rapid determination, there as using polymers can compact chemical attack.

The strength of concrete with dc is as high as 1410kg/cm2 with a short curing period.

The use of Fibrous polymer cone beans provides a high strength

Pc is visco-elasitc in nature and it will fail under restrained comp loading at stress levels which is greater than of the ultimate strength.

PC beams are more effective than concrete beam of usual steel reinforcement percentage such because utilize steel region of high tensile stress.

Polymer partially impregnated

Polymer partially impregnated or coated in dep(CID) and surface coated (SC) control partially polymer impregnated concrete is used to in the strength of concrete

Partially impregnated concrete is sufficient in situations there the major required surface persistent against chemical and mechanical attacks.

3. Explain in detail about Sulphur infiltrated concrete.

New types of composition have been produced by the recently developed techniques of impregnating porous material like concrete with sulphur. Sulphur impregnation has shown great improvement in strength.

Application of Sulphur - infiltration concrete.

Sulphur – (impregnated) infiltration can be employed in the precast industries. Sulphur infiltration concrete should found considerable use in industry situation where high corrosion resistant concrete is required. This method cannot be

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conveniently applied to cast- in place concrete Sulphur impregnation has shown area improvement in strength.

Physical propertied have been found and large improvements in watter impermeability and resistance to corrosion have been achieved. Sulphur – infiltrated concrete showed more than 4 times increase in splitting tensile strength.

Manufacturing of sulphur – infiltration

Sulphur is heated to bring it into molten condition to which coarse and fine aggregates are poured and mixed together. On cooling, this mixture gave fairly good strength, exhibited acid resistance and also other chemical resistance, but it proved to be either than ordinary cement concrete.

Procedures A:

In procedure A after 24hrs of most (cooling) curing, the specimen is dried in heating cabinet for 24 hrs at 121^{o}c. Then the dried specimen is placed in a container of molten sulphur at 121^{o}c for 3 hours.

Specimen are removed from the container, wiped clean of sulphur and cooled to room temperature for one hour and weighed to determine the sulphur infiltrated secrete.

Procedure B:

In procedure ‘B’ the dried concrete specimen is placed in an air tight container and subjected to vacuum pressure of 2mm mercury for two hour

After removing the vacuum, the special are soaked in the mother sulphur at atmosphere pressure for another half hour. The specimen is taken out, wiped clean and cooled to room temperature about one hour. The specimen is weight and the weight of sulphur impregnated is determined.

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It has found that the elastic property of sulphur infiltrated concrete has been generally improved *by)100% and also sulphur- infiltrated concrete showed a high resistance to freezing and when the moist cured concrete was disintegrated after about 40 cycle sulphur impregnated concrete is found be in fairly good conditions.

3. Explain in detail ferro cement

Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layer of continuous and relatively small size wire mess

Application of ferrocement

1. Marine application
    - Used for constructing boats, fishing vessels, barrages, docks etc
    - Water tightness, impact resistance, small thickness and light weight
2. Water supply and sanitation applications
    - Water supply tanks, sedimentation tanks, well casings, septic tanks, sanitary tanks
3. Agricultural application

    Grain storage bins, silos, water tanks, pipes linings for underground pits and irrigation channels
4. Housing applications

    Mosque domes, shelters, sheds, domed structure, precast housing elements, wall panels, sandwich panels, corrugated roofing sheets.
5. Rural energy application

    Biogas digesters, biogas holders, incinerators and panels for solar energy collectors
6. Permanent formwork

    For reinforced or prestressed concrete column beams, slabs

Materials used in ferrocement

- Cement mortar mix

    Its components are Portland cement, fine aggregate, water and admixtures materials should satisfy all required standards similar to reinforced concrete. Additives such as superplasticers, silica fumes and fly ash can also be used

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- Skeletal steel

  To form the skeleton of the structure skeletal steel is often used in the form of welded wires or a simple grid of steel wires, rods or strands

- Steel mesh reinforcement

  Steel meshes are the primary reinforcement for ferrocement. The meshes can be square or hexagonal shape , welded or in forms of sheets,

4. Explain in detail Fibre Reinforced Concrete

It is defined as a composite material consisting of mixtures of cement, mortar or concrete and discountinous, discrete , uniformly dispersed suitable fibres. continous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres

The fibres is often described by a convenient parameter called aspect ratio .It is the ratio of its length to its diameter .Typical aspect ratio ranges from 30 to 150.

Type of fibres:

i. Steel fibre:

   Commonly used fibre

   Round fibres are used diameter 0.25 to0.75mm

ii. Polypropylene and nylon fibre:

   Increase the impact strength

   Very high tensile strength

   Low modulus of elasticity and higher elongation do not contribute to the flexural strength

iii. Asbestos fibre:

   Mineral fibre

   Tensile strength of asbestos varies between 560 to 980 N\mm^2

   Higher flexural strength

iv. Carbon fibre:

   Very high tensile strength 2110 to2815 N/mm^2 and Young's modulus

   Very high modulus of elasticity and flexural strength

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Good durability

v. Glass fibre:

Very high tensile strength 1020 to 4080N / mm ^{2}

Factors effecting properties of fibre reinforced concrete:

It is the composite material containing fibres in the cement matrix in an orderly manner or randomly distributed manner. Its properties depend upon the efficient transfer of stress between matrix and fibres which largely depend on the type of fibre, fibre geometry, fibre content, orientation and distribution of the fibres, mixing and compaction techniques of concrete and size and shape of the concrete.

1) Relative fibre Matrix stiffness:

The modulus of elasticity of matrix must be much lower than that of fibre for efficient stress transfer .low modulus of fibres such as nylons and polypropylene are unlikely to give strength improvement but they help in the absorption of large energy and impart greater degree toughness and resistance to impact. High modulus fibres such as steel glass and carbon impart strength & stiffness to the composites

2) Volume of fibres

Strength of the composite largely depends on the quantity of fibres. It increase the tensile strength & toughness of the composite . use of higher percentage of fibre is likely to cause segregation and harshness of concrete and motar

3) Aspect ratio of the fibre

Aspect ratio of 75, increase in the aspect ratio increases the ultimate strength of the concrete linearly. Beyond 75, relative strength and toughness reduced.

4) Orientation of fibres

Conventional reinforcement, bars are oriented in the direction desired while fibres are randomly oriented

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Fibres aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibres

5) Workability & compaction of concrete

Steel fibre decreases the workability considerably

Poor workability is non-uniform distribution of fibres. The workability & compaction standard of the mix is improved through increased water/cement ratio or by the use of some kind of water reducing admixtures.

6) Size of coarse aggregate

Maximum size of the coarse aggregate should be restricted to 10 mm, to avoid appreciable reduction in strength of the composite

Application

Overlays of air field, road pavements, industrial flooring, bridge decks, canal lining , explosive resistant structures refractory linings

Fabrication of precast products like pipes boats, beams, staircase steps, wall panels, manhole covers

5. Explain in detail fiber reinforced polymeric meshes

Fiber reinforcements made from carbon glass, aramid, or other high performance materials embedded in polymeric matrices in the form of bars,tendons and strands are as produced and used.

- Advantages:

  Good resistance towards corrosion

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High unit weight

Easy to handle

Good damping and fatigue behavior

Convenient to use for repairing structure

- Disadvantage:

  High cost

  Low shear strength

  Low ductility

  Susceptibility to stress rupture effect

- Advantages of Ferrocement:

  Favorable tensile property

  High ductility

  High resistance to cracking width and crack opening

  Ability to undergo large deflection

  Improved impact resistance and toughness

  Good fire resistance

  Good impermeability

  Low strength to weight rate

  Low maintainance cost

Mechanical properties:

Homogeneous,isotropic properties in two directions because of two way action, high tensile strength and a high modulus of rupture.Its tensile strength can be of the same order as its compressive strength.High reinforcement ratio in both tension and compression and in both directions.Large specific surface of reinforcement which is

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one to two orders of magnitude that of reinforced concrete.Its elongation upto failure under tension or its deflection at maximum load increases with anincrease in the number of mesh layers used.Its ductility increases with the volume fraction and specific surface of reinforcement.Two dimensional reinforcement and better resistance towards punching shear as well as resistance to impact compared to reinforced concrete.

Construction method:

Skeletal armature method

Closed mould method

Integral mould method

Open mould method

1. Skeletal armature method

In this method a framework of reinforcing bars is constructed to which a layer of meshes is applied.Next mortar is applied on one side and forced through the mesh until a slight excess appears on the other side

The skeletal framework of reinforcing bars can assume any shape based on requirement.The diameter of the steel bars depends on the size of the structure. skeletal steel is cut to a specified length and bent to suit the shape

- Advantage:

  No elaborate form material required

  Easy to patch up the whole area from both slides

  Good penetration

  Easy to repair when damaged

- Disadvantage:

  Time consuming

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Application of mortar from one side may be difficult for a thick mesh system

Galvanic corrosion may develop between the mesh and skeletal stee

2. Closed mould method

in this method several mesh or mesh and rod compination are held together in position against the surface of the mould. Motar is applied from the open side. The mould either remains a permanent part of the structure or can be removed and reused. In this method a thin layer of mortar is placed first and allowed to settle over which the mesh is placed an dthe second layer of mortar poured. This procedure is repeated until require numbers of layers are placed

3. Integrated mould method

This method involves a semi rigid framework. An integral mould may be formed using foam material such as polystyrene as the core. Mortar is poured from both sides of mould. The mould is left inside the ferro cement itself

4. Open mould method

Used for boat building. The open mould is made of lattice wood or some other suitable material and stiffened by ribs. The mortar is applied through one side only. To facilitate mould removal the mould is covered with release agent or entirely covered with poltethylene sheets

Unit-4

16 Marks

1.. Briefly explain about vacuum concrete.

High water cement ratio is harmful to the overall quality of concrete, where as low water-cement ratio does not give enough workability for concrete to be compacted hundred percent.

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Generally higher workability and higher strength or very low workability and higher strength do not go hand in hand.

Now, vacuum process of concreting enables to meet this conflicting demand and this process helps a high workable concrete to get high strength.

Vacuum Concrete:- Only about half of the water added in concrete goes into chemical combination and the remaining water is used to make concrete workable.

After laying concrete, water which was making concreting workable is extracted by a special method known as “vacuum method”. This water left in this concrete is only that which is to go in chemical combination and hence resulting concrete become very strong.

Manufacturing Process:

General arrangement for vacuum concrete. Process

The equipment essentially consists of:-

iv. vacuum pump
v. water separator and
vi. filtering mat

The filtering consists of a backing piece with a rubber seal all round the periphery

A sheet of expanded metal and then a sheet of wire gauge also forms a part of filtering mat.

The mat of the suction mat is connected to the vacuum pump. When the vacuum pump operates, suction is created with in the boundary of the suction mat and the excess water is sucked from the concrete through the fine wire gauge.

At least one face of the concrete must be open to the atmosphere to create difference of pressure. The contraction of concrete caused by the loss of water must be vibrated.

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The vacuum processing can be carried out either from the top surface or from the side surface. There will be only nominal difference in the efficiency of the top processing or side processing.

2.. Explain in detail about Gunite.

Gunite can be defined as mortar conveyed through a hose and pneumatically projected at a high velocity on to a surface.

The development of this method is by the introduction of course aggregation and the reduction of cement makes the process economical.

Guniting was first introduced in 1900 and this process is mostly used for pneumatically application old mortar of less thickness.

Shotcrete is a recent development on the similar principle of guniting for achieving greater thickness with small coarse aggregate.

There are two process in use, namely;-

Wet mix process in use, namely

Dry mix process and the dry mix process is more successful.

Dry mix process;-

The dry mix process consists of a number of stages and calls for some specified plant.

General arrangement of apparatus in gunite system.

The stages involved in the dry mix process

i. Cement and sand are thoroughly mixed.
ii. The cement/ sand mixture is fed into a, special air pressurized mechanical feeder termed as Gun.
iii. The mixture is metered into the delivery hose by a feed wheel or distributor with in the gun.

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iv. The material is carried by compressed air through the delivery hose to a special nozzle. The nozzle is fitted inside with a perforated manifold through which water is sprayed under pressure and intimately mixed with the sand /cement jet.

v. The web motor is jetted from the nozzle at high velocity onto the surface of the gunited.

The stages involved in the wet mix process

i. In this process, the concrete is mixed with water as for ordinary concrete before conveying through the delivery pipeline to the nozzle, at which point it is jetted by compressed air, onto the work in the same way as that if mix process.

ii. The wet process has been generally desired in favour of the dry mix process, owing to the greater success of the latter.

3. Explain Rust Eliminators

Rust converter coating system for corrosion control

Steel starts corroding in concrete when chloride level reaches 0.7 Kg/m^2

Steel normally does not corrode in concrete where this level is less than 0.7 Kg/m^2

Other contaminants include polluted air. Carbonation reduces the pH level in concrete and allows future deterioration of steel rebars. It has better chemical resistance, weather resistance. This coating has penetration through all the stratified rust layer, reactions and conversion of rust stablisation

The coating is water bared with good coverage of mechanical surface treatment as rust removal in rotars such as scrappling, brushing or powder cleaning are eliminated by rust converter coating. Future it react with rust and forms a metallic organic protective film which neutralizes the corrosion process and provides an ideal solution to completely passivate the tightly bound rust removing, chemically preventing it from participating in further corrosion.

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4.Describe the preliminary procedures in demolition of a structure.

The step by step procedures are as follows;

Preliminary Investigation

Demolition is a highly skilled and dangerous activity in terms of damage to life and property and there are certain basic factors to consider before a contract is placed:

- The demolition contractor should have ample experience of the type of work to be offered;
- Fully comprehensive insurance against all risks must be maintained at all times;
- An experienced supervisor should be continuously in charge of the work;
- The contract price should include all safety precautions included in the relevant building regulations;
- The completion date should be realistic, avoiding and need to take risks to achieve the date.

Preliminary Considerations

Demolition operations are the subject of strict legal controls - there is a substantial body of legislation and a great deal of case law relating to such operations. There may also be some regulations which impose additional restrictions: for example, action against nuisance such as noise and dust. The BSI Code of Practice for Demolition BS 6187 exerts further influence, in that if the demolition contractor does not observe the recommendation of the Code, this may well influence a Court's decision as to his liability in any legal proceedings.

General Site Provisions

A. Plant and Equipment

   Must only be operated by skilled operators and must be regularly serviced.

B. Protective Clothing

   Buildings where chemicals have been stored or where asbestos, lead paint, dust or fumes may be present will require specialized protective clothing, e.g. respirators, helmets, goggles, footwear, gloves, etc. Projecting nails, pieces of metal, etc. resulting from demolition can cause accidents.

C. Shoring and Underpinning

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The demolition contractor has a legal obligation to show technical competence when carrying out the work. When removing sections of the building which could have leave other parts unsafe, adequate temporary supports and shoring etc. must be provided.

D. Working Areas

These will need to be well signposted and clear warnings given that demolition work is in progress. This may include the necessity for some kind of lighting.

E. Debris

Sections of the building must not be overloaded with debris either on suspended floors or against party walls.

F. Weather Conditions

These can affect safety. Strong winds or drifting snow against unsafe walls, suspended floors etc. which are unpropped may lead to collapse.

G. Flooding

The build-up of water can sometimes be hazardous.

H. Overhead Cables

An crane heights etc. must be checked against the height of any surrounding overhead cables to avoid damage and cutting off supplies etc.

I. Scaffolding and Hoarding

These must be constructed and illuminated to the relevant building regulations.

J. Security

The demolition site and any partially demolished buildings must be properly secured against entry.

K. Dust

Should be kept to a minimum by spraying with water when necessary.

L. Noise

Suppressors and silencers, particularly on compressors etc., should be used to keep noise levels to a minimum.

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Supervision of Demolition Work

A method statement showing how the demolition work is to be carried out should be prepared and the contractors should appoint a "competent person" to supervise the demolition work.

5.Explain the demolition process of a damaged structure.

As an intrinsic part of the construction process, efficient demolition of structures is an important factors deserving careful consideration in the evolution of any redevelopment project.

Modern emphasis is on reduction of construction periods to ensure economic redevelopment, coupled with increasing town centre regenerating calling for careful demolition on constructed and restricted site, have resulted in more consideration being given to demolition as part of the process of construction and redevelopment than was typical in previous times.

Developing a Demolition Strategy

The strategy will need to take into account the method of construction used for the original building and its proximity to other buildings, structures and the general public. These factors, together with location, the cost and availability of tipping and disposal and the desirability and economics of reuse, must be taken into account in the development of an appropriate strategy for the demolition of a structure.

Building Information

Information on buildings in terms of "as built" drawings and structural details may often be unavailable or unreliable, and consequently some investigative site and desk work may be necessary, both to ascertain the way in which the building was originally constructed, and to identify the stresses and strains which exist within it.

In order to plan the most efficient method of demolition, it is important to have a full understanding of the method of construction and the stress patterns imposed upon the building. Failure to do so may result in risks to the safety of both those involved in the demolition and those in close proximity to the site.

Selecting Appropriate Techniques

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Majors factors to be considered in selecting an appropriate technique include:-

- Safety of personnel and public
- Working methods
- Legislation applicable
- Insurance cover

Preliminary Aspects Prior to Site Demolition Work

Considerations should be given to:-

- Conducting a site and building survey, with a structural bias;
- The examination of drawings and details of existing construction where available;
- The preparation of details and drawings from site survey activities where no such information is available;
- Establishing previous use of premises, especially with regard to flammable substances or substances hazardous to health or safety;
- Programming the sequence of demolition work;
- The preparation of a Method Statement.

Method statement

- A detailed health and safety method statement, produced before work starts, is essential for safe working. It should include a full risk assessment, identify problems and their solutions, and form a reference for the site supervision.

- The method statement should be easy to understand, agreed by and known to all levels of management and supervision, and should include such matters as:-

- The sequence and method of demolition or dismantling of the building or structure with details of personnel access, working platforms and machinery requirements;

- Details and design of any temporary supporting structures to be used during the demolition process;

- Specific details of any pre-weakening on structures which are to be pulled down or demolished with explosives;

- Arrangements for the protection of personnel and the public and the exclusion of unauthorized persons, with details of areas outside the site boundaries that may

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occasionally need to be controlled to improve safety during critical aspects of the work;

- Details of the removal or making safe of electrical, gas and other services and drains;
- Details of temporary services available or required for the contractor's use;
- Details of the methods for detailing with flammable materials and gases which may have been retained or deposited as residue in process machinery, pipework or storage;
- Details of methods to establish the presence of hidden or other substances that may be hazardous to health, the methods to be used for their disposal, and any necessary protective equipment;
- Arrangements for the control of site transport used for the removal of demolition debris.

6.Describe in detail about the various demolition techniques.

In many circumstances, buildings and structures should be demolished in the reverse order to their erection, although where partial demolition is involved a more careful evaluation of the nature of the effects of the demolition is necessary.

Normally, the demolition contractor is able to adopt a method of work which:-

- gradually reduces the height of the building; or
- arranges the deliberate controlled collapse of the building or structure so that work can be completed at ground level.

Demolition Technique Selection

The choice of demolition technique will depend on the nature of the building or structure and its environment. Risks to the public, operatives involved in the demolition process and adjacent structures and buildings should be considered.

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Demolition techniques may be categorized as:-

- Piecemeal demolition, using hand-held tools or machines, to reduce the height of the building or structure gradually;

- Deliberate controlled collapse, demolition to be completed at ground level.

Piecemeal Demolition by Hand

Demolition of buildings or structure by hand-held tools such as electric or pneumatic breakers, sometimes as a preliminary to using other methods, should be carried out, where practicable, in the reverse order to the original construction sequence. Lifting appliances may be necessary to hold larger structural members during cutting and for lowering severed structural members and other debris. Chutes may be used to discharge debris into a vehicle or hopper. Foundations would normally be grubbed up by excavation machines.

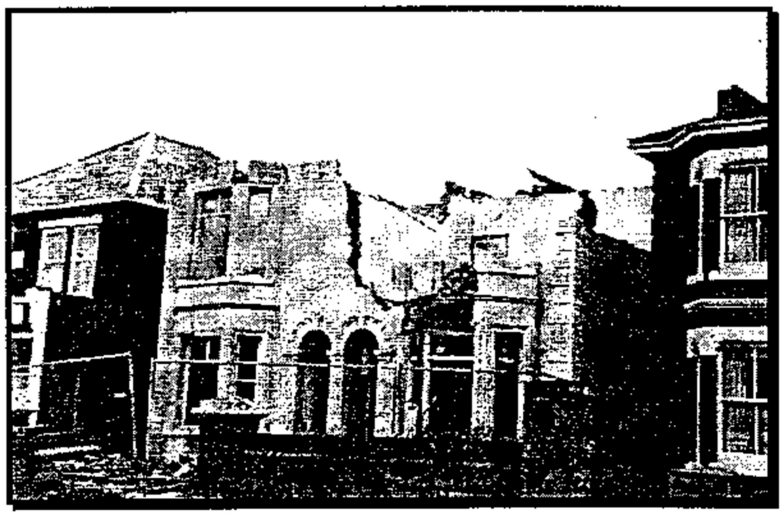

Figure 1: Piecemeal demolition

By Machine

Simple roof structures supported on wall plates should normally be demolished to the level of wall plates by hand, but if this may involve unsafe working, then demolition totally by machine may be appropriate.

Where a building that is to be demolished by machine is attached to another structure, the two properties should be separated by the use of hand methods before the main demolition process begins.

When any part of a building is being demolished by a balling machine, pusher arm or similar equipment, only the machine operator and banksman should be allowed close to

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the working area. The cabs of all machines should be strong enough to protect the operator against the fall of debris. In particular, the windscreen and rooflight should be of shatterproof material and guarded by a grille of steel bars or a substantial mesh.

A. Balling Machine
   Balling machines generally comprise a drag-line type crawler chassis fitted with a lattice crane jib. The demolition ball, with a steel anti-spin device, is suspended from the lifting rope and swung by the drag rope.

   Balling should only carried out by skilled operatives under the control of experienced supervisors using well maintained machines adequate for the proposed duty and standing on a firm, level base.

   The manufacturer should be consulted before a machine is used for balling to establish any restrictions on the type or length of jib or the weight of the ball.

Balling operations subject cranes to dynamic stresses and wear, and the ball chosen should have the minimum weight necessary for effective use. In many cases, demolition balls of quite light weight will be adequate.

Floors should be demolished by dropping the ball on the highest remaining floor and allowing the debris to fall inside the building. The debris should be removed regularly to prevent excessive weight accumulating on the lower floors.

Walls or columns can be demolished either by swinging the ball in line with the stationary jib, using the drag rope, or by slewing the jib. The ball should not swung by derricking the jib.

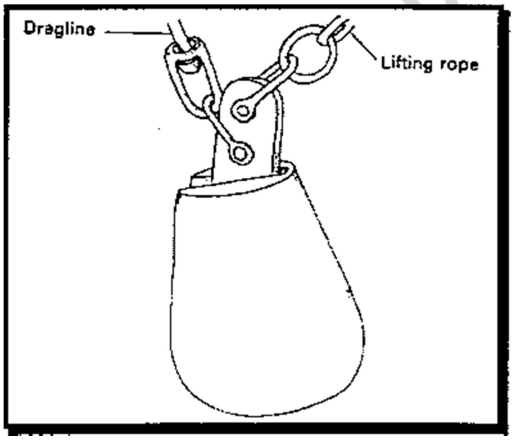

Figure 2: Demolition ball

B. Hydraulic Pusher Arm

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Articulated, hydraulically-powered pusher-arm machines are normally mounted on a tracked or wheeled chassis, and have a toothed plate or hook for applying for applying a horizontal force to a wall. The machine should stand on a firm level base and apply force by a controlled movement of the pusher arm.

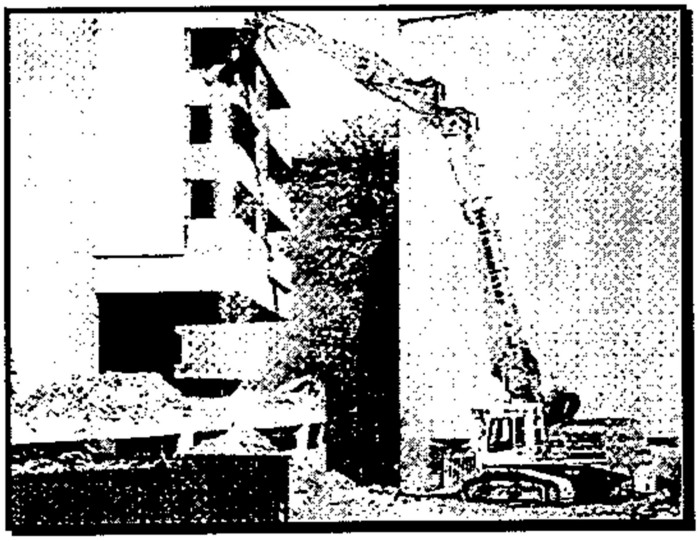

Figure 3: Hydraulic pusher arm

C. Explosives

If explosives are to be used for demolition, the planning and execution, include pre-weakening, should be under the control of a person competent in these techniques. For large demolition, the competent person is likely to be an experienced explosive engineer; for smaller work, a shot-firer may be sufficient.

When the use of explosives is contemplated, it is usual to employ a technique that will ensure the total demolition of the whole building by staging a controlled collapse. The explosive charges are set and fired in a sequence that will weaken the structure in such a way that the building collapses in upon itself.

Although we tend to think of explosives as devices producing spectacular bomb-like explosions, the use of non-explosive "explosives" is now at an advanced stage. These non-explosive techniques are essentially expanding charges that achieve the same results as explosives but without the noise and initial devastating blast.

D. Overturning - Wire Rope Pulling

This method is the application of a horizontal force at a high level by pulling with wire ropes attached to winches or vehicles, and allowing the impact on overturning to demolish the building or structure. An adequate steel cab or cage should protect the winch or the pulling vehicle and the operator.

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Building over 21m high should not normally be demolished by rope pulling.

E. Impact Hammer and Nibblers

Impact hammers normally have a track- or wheel- mounted chassis, an articulated boom, and a heavy duty pick vibrated by hydraulic or pneumatic power to demolish concrete or masonry.

Nibblers use a rotating action to snap brittle materials such as concrete or masonry. In either case, material should be removed from the top of walls or columns in courses not greater than 600mm in depth, steel reinforcement should be cut separately as necessary.

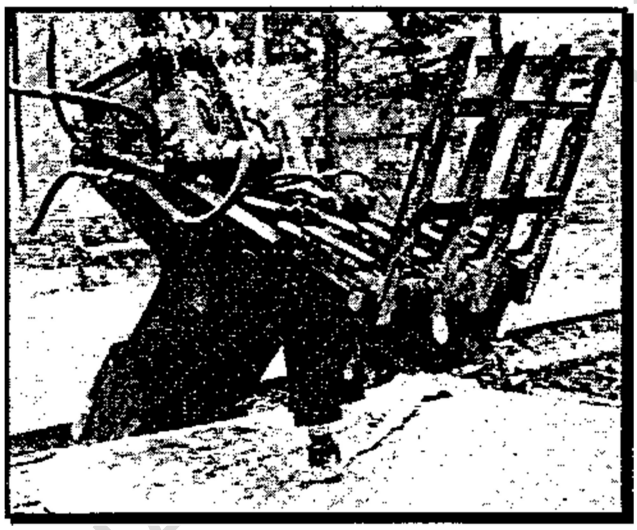

Figure 5: Nibblers

Pre-Weakening

Buildings and structures normally have structural elements designed to carry safely the loading likely to be imposed during their life.

As a preliminary to a deliberate controlled collapse, after loads such as furnishings, plant and machinery have been removed, the demolition contractor may be able to weaken some structural elements and remove those new redundant. This pre-weakening is essentially a planned exercise and must be preceded by an analysis of its possible effects on the structure until it collapses, to ensure that the structural integrity of the building is not jeopardized accidentally. Insufficient information and planning relating to the structure may result in dangerous and unsafe work.

Deliberate Controlled Collapse

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The deliberate collapse of the whole or part of a building or structure requires particularly high standards of planning, supervisions and execution, and careful consideration of its effect on other parts of the structure or on adjacent buildings or structures. A surrounding clear area and exclusion zone are required to protect both personnel and property from the fall of the structure itself and debris which may be thrown up by the impact.

The collapse is usually achieved either by removing key structural elements (e.g. with explosive charges) or by wire rope pulling at a high level to overturn the structure. The possible modes of failure must be studied to ensure that the method selected will produce the required pattern of collapse. If the operation is not successful, the remaining structure may be extremely dangerous for the completion of the demolition.

Demolition by deliberate controlled collapse is not usually appropriate for prestressed concrete except for simple pre-tensioned floor planks or slabs.

7. Describe in detail about the impulsion method of demolition of structures.

An **implosion** is an event where something collapses inward, because the external atmospheric pressure is greater than the internal pressure. For example, if you pumped the air out of a glass tube, it might implode. When a building is surrounded by other buildings, it may be necessary to **"implode"** the building, that is, make it collapse down into its **footprint**. You can demolish a stone wall with a sledgehammer, and it's fairly easy to level a fivestorey building using excavators and wrecking balls. But when you need to bring down a massive structure, say a 20-story skyscraper you have to haul out the big guns. Explosive demolition is the preferred method for safely and efficiently demolishing larger structures.

The basic idea of explosive demolition is quite simple: If you remove the support structure of a building at a certain point, the section of the building above that point will fall down on the part of the building below that point. If this upper section is heavy enough, it will collide with the lower part with sufficient force to cause significant damage. The explosives are just the trigger for the demolition. It's gravity that brings the building down.

Demolition blasters **load** explosives on several different levels of the building so that the building structure falls down on itself at multiple points. When everything is planned and executed correctly, the total damage of the explosives and falling building material is sufficient to collapse the structure entirely, so clean-up crews are left with only a pile of rubble.

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Methodology

In order to demolish a building safely, blasters must map out each element of the implosion ahead of time. The first step is to examine **architectural blueprints** of the building, if they can be located, to determine how the building is put together. Next, the blaster crew tours the building (several times), jotting down notes about the support structure on each floor. Once they have gathered all the raw data they need, the blasters hammer out a plan of attack. Drawing from past experiences with similar buildings, they decide what explosives to use, where to position them in the building and how to time their **detonations**. In some cases, the blasters may develop 3 – D computer model of the structure so they can test out their plan ahead of time in a virtual world.

The main challenge in bringing a building down is controlling which way it falls. Ideally, a blasting crew will be able to tumble the building over on one side, into a parking lot or other open area. This sort of blast is the easiest to execute, and it is generally the safest way to go. Tipping a building over is something like felling a tree. To topple the building to the north, the blasters detonate explosives on the north side of the building first, in the same way you would chop into a tree from the north side if you wanted it to fall in that direction. Blasters may also secure steel cables to support columns in the building, so that they are pulled a certain way as they crumble. Sometimes, though, a building is surrounded by structures that must be preserved. In this case, the blasters proceed with a true implosion, demolishing the building so that it collapses straight down into its own **footprint** (the total area at the base of the building). This feat requires such skill that only a handful of demolition companies in the world will attempt it.

Blasters approach each project a little differently, but the basic idea is to think of the building as a collection of separate towers. The blasters set the explosives so that each "tower" falls toward the center of the building, in roughly the same way that they would set the explosives to topple a single structure to the side. When the explosives are detonated in the right order, the toppling towers crash against each other, and all of the rubble collects at the center of the building. Another option is to detonate the columns at the center of the building before the other columns so that the building's sides fall inward.

According to Brent Blanchard, an implosion expert with the demolition consulting firm Protect documentation services virtually every building in the world is unique. And for any given building, there is any number of ways a blasting crew might bring it down. Blanchard notes the demolition of the
Hayes Homes, a 10-building housing project in Newark, New Jersey, which was demolished in three separate phases over the course of three years. "A different blasting firm performed each phase," Blanchard says, "and although all of the buildings were identical, each blaster chose a slightly different type of explosive and loaded varying numbers of support columns. They even brought the buildings down in different

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mathematical sequences, with varying amounts of time factored in between each building's collapse."

Generally speaking, blasters will explode the major support columns on the lower floors first and then a few upper stories. In a 20-story building, for example, the blasters might blow the columns on the first and second floor, as well as the 12th and 15th floors. In most cases, blowing the support structures on the lower floors is sufficient for collapsing the building, but loading columns on upper floors helps break the building material into smaller pieces as it falls.

This makes for easier clean-up following the blast. Once the blasters have figured out how to set up an implosion, it's time to prepare the building. In the next section, we'll find out what's involved in predetonation prepping and see how blasters rig the explosives for a precisely timed demolition.

8. Discuss in detail about any case study on demolition of structures.

HQrs SC Pune convened a board of Officers on 4.7.1997 at General Area of old KV Bolarum Complex, Secunderabad for assessing the requirement of special repairs to a group of buildings vide convening order No:300050/97/2/Q(wks) dated 4.6.1997. The purpose shown in the Board proceedings is quoted below:

"To assess the requirement of special repairs to buildings and roads and recommend demolition of unsafe / uneconomical buildings at old KV Bolaram Complex".

FINDINGS OF THE BOARD:

The Board found that all the buildings located in the complex were of 1850 to 1910 vintage constructed with brick masonary and mud mortar and served more than their expected life. The buildings were in occupation by Kendriya Vidyalaya, Bolaram for a considerable time and were vacated during 1989-90. All buildings were in bad shape due to vintage and needed extensive repairs.

RECOMMENDATIONS OF THE BOARD:

The Board recommended urgent special repairs to 13 permanent / Temporary buildings inorder to bring these buildings to habitable condition and to ensure structural safety. The special repairs was estimated to be Rs.40.18 lakhs.

The board also recommended six buildings for demolition as they were found to be in dilapidated condition and unsafe and beyond economical repairs. The board recommended sanction of demolition of the said six buildings and to initiate new works for recoupment of these buildings through a separate board of officers urgently (as the work on the new toilets is to be completed by the time of completion of the proposed

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special repairs so that troops occupying the buildings after special repairs will have toilet facilities)

Based on the recommendations of the Board, the GOC-in-C S.C. vide letter No:300050/97/2/2(wks) dated 25.10.1997 accepted necessity and accorded Admin Approval for the special repairs at an estimated cost of 42.05 lakhs. The Admin Approval included the demolition of old buildings also as recommended by the Board. 32 weeks time was given for completion of work. Based on the sanction a contract agreement was concluded for Rs.43.45 lakhs by CE(Fys) Hyd zone vide CA No: CE(Fys)/ Hyd / Sec / 16 of 97-98. In addition, the following works were also executed to bring the buildings into use.

CA / Sanction No & Date	Amount	Nature of work done
1.CWE(S)/SEC-E/M/25 of 97-98	16.63 lakhs	Augmentation of external electrical, water supply, sewage disposal etc (capital work)
2. HQ ASA letter No:4045/OTM/Q3W dt.1.12.97 and CA No: 35/ASA/SEC/SR/97-98	3.97 lakhs	Repairs to Temporary Buildings T.12 (Revenue work)
HQ ASA letter No:4045/OTM/Q3w(i) dt.3.12.97	3.20 lakhs	Repairs to Temporary Buildings T.12-1 (Revenue work)
3. HQASA letter No:4093/Q3 dt.9.5.98	80,000	Provision of Gate for Army Dental College (Revenue Work)
	Total:24.60 lakhs	

Thus a total sum of Rs.68.05 lakhs (43.45 + 24.60 lakhs) was spent on the buildings in order to make them habitable. The work was completed in all respects in Jan ’99 and GE(S) Secunderabad vide his letter No:2311/254/E2 dated 28.1.99 requested the

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station HQrs to instruct the users concerned to take over the accommodation from MES.

The RAO MES Secunderabad, during review of the GE's accounts found it curious that a huge sum of Rs.68 lakhs was spent on barracks lying vacant for almost 10 years and therefore probed the matter from the GE/CWE records. The detailed examination of the records brought out the following interesting facts:

1. HQrs convening order dated 4.6.97 to assess the requirement of special repairs to the unused barracks which ultimately resulted in spending of more than 68 lakhs on unused barracks was only a sequel to the proposal to establish an Army Dental College at Secunderabad to be run by a regimental institution viz., Army Welfare Education Society (AWES).
2. As the project involved considerable expenditure, it was proposed to house the college initially in the unused barracks by carrying out special repairs and shift to permanent location later.
3. The cost, time and all other aspects involved in the matter were brought in the CWE Secunderabad Engineers appreciation dated 19.5.97 (copy enclosed as Annexure - A)
4. The need to reappropriate the land & buildings for use by the Army Dental College was clearly brought out by the Engineering Appreciation report of CWE.
5. The necessary reappropriation sanction was also called for from Station HQrs by CWE Secunderabad vide their letter No:24225/17/E2 dated 28.10.97 immediately after issue of Admin Approval dated 25.x.97 for which no action was taken by the Admin Authorities.
6. Neither the Board proceedings nor the Admin Approval and other subsequent sanctions brought out the purpose of the whole exercise thus effectively concealing the matter from audit.

In the light of the above findings, the RAO(MES) Secunderabad placed the entire expenditure under objection and reported the matter to CDA Secunderabad for further necessary action

Unit-5

16 Marks

1. Explain the various techniques available for repair of cracks.

The following techniques are available for repairing cracks

a. Bonding with epoxies
b. Routing and sealing

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c. Stitching
d. External stressing
e. Blanketing
f. Overlays
g. Grouting
h. Autogenous healing

BONDING WITH EXPOXIES

Cracks in concrete may be bonded by the injection of epoxy bonding compounds under pressure.

Usual practice is to drill into cracks from the face of the concrete at several locations. Water or a solvent is injected to flush out the dirt and foreign matter and allowed to get cleaned through this process. The surface is then allowed to dry. The epoxy is injected into the drilled holes until it flows out through the order holes.

ROUTING AND SEALING

This method involves enlarging the cracks along its exposed surface, filling and finally sealing it with a suitable material.

This is the simplest and most common technique for sealing cracks and is applicable for sealing both fine pattern cracks and larger isolated. The cracks should be dormant unless they are opened up enough to put in a substantial paten in which case the repair may be more property termed as “Blanketing”.

Routing and Sealing of leaking cracks preferably should be done on the pressure face so that the water, aggressive agents can not penetrate the interior of the concrete and cause side effects such as swelling, chemical attack or corrosion of rebars etc.

On road pavements it is common to see cracks which have been sealed by pouring hot tar over them. This is a simple and inexpensive way where thorough water tightness of the joint is not important.

STITCHING

The tensile strength of a cracked concrete section can be restored by stitching in a manner similar to sewing cloth.

Precautions to be followed:

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I. Any desired degree of strengthening can be accomplished but it must be noted that strengthening also tends to stiffen the structure locally.

II. Stitching the crack will tend to cause its migration else where in the structure. For this reason strengthening the adjacent areas of cracks have to be made to take care of additional stresses. More over the stitching dogs should be of variable length, orientated and so located that the tension transmitted across the crack does not devolve on a single plane of the section but is spread over an area, Strengthening of the adjacent sections of concrete may consist of external reinforcement embedded in a suitable overlay material.

III. Where there is a (leakage of) water problem, the crack should be sealed as well as stitched so that stitches are not corroded.

IV. Stress concentrations occur at the ends of the cracks; hence the spacing of the stitching dogs should be reduced at such locations. The stress concentrations at each ends of the cracks can be relieved by drilling holes near them:

V. Wherever possible both sides of cracks have to be stitched to prevent bending action on dogs due to movements of the structure.

In bending members it is possible to stitch one side of the crack but this should be the tension side of the section where movement is originating.

If the member is in a state of axial tension then a symmetrical placement of the dogs is a must.

vi. If the stitching is to supplement the strength of the existing section, the deformation must be compatible. The dogs must be grouted with a non-shrink or expandable mortar so that they have a tight fit thus the movement of the crack will cause the simultaneous stressing of both old and new sections. The holes for the legs of the dogs should be filled with grout.

vii. The dogs are thin and long and to cannot take much of compressive force. The dogs must be stiffened and strengthened by encasement in an overlay or some similar means.

Instead of steel rods or flats used us dogs, the same be replaced with ferrocement which is made effective using chicken mesh or chicken mesh in conjunction with welded mesh as the case may be, Employment of cement mortar 1:2 or 1:2:5 with a water cement ratio of 0.45 is recommended for protecting the steel reinforcement mesh.

EXTERNAL STRESSING

Development of cracking in concrete is due to tensile stress and can be arrested by removing these stresses. Further the cracks can be closed by including a compressive force sufficient to over come the tension a residual compression.

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The compressive force is applied by using the prestressing wires or rods. The principle is similar to stitching except that the stitches are tensioned. But additional anchorage's are to be provided for prestressing wires.

The compressive force also may be applied wedging (ie) opening the Crack and filling it with an expanding mortar, by jack and grouting or by actually driving wedges.

BLANKETING

Blanketing is similar to routing and sealing on a large scale and applicable for sealing both active and dormant cracks and joints.

Type of Blanket joints

i. Type I - A elastic sealant filled joint

Where an elastic sealant is used, the serial is one wheel returns to original shape when the externally induced stress is proved.

ii. Type II - A mastic filled – Joint

This similar to the sealant chase of a Sealant except that the bon breaker is omitted and the sealant is bonded to the as well as to the side of the chase. The sealant is mastic rather than a compore. I with elastic properties. They are used where the anticipated movements are small.

iii. Type III - A mortar plugged joint
iv. Type IV - A crimped water bar

OVERLAYS

Overlays are used to seal cracks. They are useful and desirable where the are large numbers of cracks and treatment of individual defect would be expensive.

i. Overlay for active cracks
   Seating of active cracks by the use of an overlay should be extensible but not flexible.
ii. Overlay for dormant cracks
   Any type of overlay may be used to seal the dormant type of cracks.

GROUTING

Grouting can be performed in a similar manner as the injection of an epoxy. However the use of an epoxy is the better solution except where considerations for the resistance of cold weather prevent such use in which case grouting is the comparable alternative.

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An alternative and better method is to drill down the length of the crack and grout it so as to form a key. This is applicable only when the cracks runs approximately in a straight line and are inaccessible at one end.

The grout key functions prevent relative transverse movements of the sections of concrete adjacent to the crack. It also prevents leakage through the crack.

AUTOGENOUS HEALING

The inherent ability of concrete to heal cracks within “autogenous healing”. This is used for sealing dormant cracks such as precast units cracked in handling of cracks developed during the precast pilling sealing of cracks in water hands and sealing of cracks results of temporary conditions. This effect also provides some increase in strength of concrete damaged by vibration during setting and concrete disrupted due and thawing.

The by which healing is the calcinations of and the Calcium Hydroxide in cement paste by CO_2 in the surrounding air and the resulting: $CaCo_2$ and $Ca(OH)_2$ crystals precipitate accumulate and grow out the cracks. The crystals interlace and twine producing a mechanical bending which is supplemented by a chemical bonding between adjacent crystals and being cry Is and the surfaces of paste and aggregates. As a result some of the strength is restored across the cracked section and the crack is sealed.

2. Explain the various techniques to repair spalling and disintegration of concrete.

a. Jacketing
b. Pneumatically applied mortar or Concrete (guniting/shot circuiting.
c. Prepacked concrete
d. Replacement for concrete
e. Dry pack
f. Over lays
g. Epoxy resins
h. Protective surface treatments

JACKETING

Jacketing consists of restoring or increasing the section of an existing member by encasing it in a new concrete. This method is useful for protection of section against further deterioration by providing additional to in member.

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PNEUMATICALLY APPLIED MORTAR

Pneumatically applied mortar is used for the restoration of when the location of deterioration is relatively at shallow depth. It can be used on vertical as well as on horizontal surfaces and is particularly restoring surfaces spalled to corrosion of the reinforcement. Damaged concrete elements also retrofitted using this method. This also has known as gunning or shotcreting techniques.

PREPACKED CONCRETE

Well adapted for under water works and other where accessibility is a problem.

REPLACEMENT OF CONCRETE

Consists of replacing the defective concrete with new concrete of conventional proportions placed in a conventional manner.

This is useful when the volume of material to be replaced is large and where repairs occurs a great depths (i.e.) several distance deep and where the area to be repaired is accessible.

DRY PACK

Dry packing is the hand placement of a very dry mortar and subsequent tamping or ramming of the mortar into place producing an intimate contact between the old and new concrete work.

OERLAYS

Overlays may be used to restore a spelling or disintegrated surface or to protect the existing concrete from the attack of aggressive agents. Overlays used for this purpose include concrete or mortar, bituminous compounds etc. Epoxies should be used to bond the overlays to the existing concrete surface.

For overlays following are used.

- Pneumatically applied mortar
- Sand-Cement slurry

EPOXY RESINS

These are organic compound which when activated with suitable hardening agents form strong chemically resistant structures having excellent adhesive properties. They are used as binders or adhesives to bond new concrete patches to existing surfaces or

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hand together cracked portions. Once hardened, this compound will not melt, flow or bleed. Care should be taken to place the epoxy within the pot life period after mixing.

PROTECTIVE SURFACE COATINGS

During of concrete can be substantially improved by preventive maintenance in the form of weather proofing surface treatments. These treatments are used to seal the concrete surface ad to inhibit the intrusion of moisture or chemicals. Materials used for this purpose include.

Oils such as linseed oils, petroleum etc.

Silicones used to seal concrete and masonry structures against moisture.

3. Describe the various strengthening techniques to overcome low member strength.

The following are the various techniques to overcome low member strength:

Increasing the depth with reinforcement

The existing seam is exposed at the tension (bottom) side by removing the cove4r concrete. Additional reinforcements are placed below and integrity is obtained by either welding or typing with the existing reinforcement. The reinforcement is protected by concreting the extra by placing temporary form work.

Increasing the width

Procedure as outlined above is followed except that the same is applied to sides because of restriction in headroom requirements of the existing beam.

Providing an overlay

If the situation permits to have un overlay on ship at their the began is increased which increases, the capacity, this method in application.

Bonding with metal plates

On the tension side of the beam 2to 3mm steel plates are to the existing beam to increase its capacity. The glue or adhesive should compatible with the existing concrete with behavioral characteristics under load addition to providing integrity with parent member.

Repairing techniques for distress due to direct shear.

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Use of external clamps

The distress is due to inadequate stirrups either due to deficiency in the of provision of C- stamps, U-clamp fixed externally along the length of beam to provide adequate these will be protected by covering with rich mortar or concreting as the a later stage.

Use of steel plates

Instead of the procedure described above, steel equal to the depth of beam (rib portion) is glued along the length of the sides to increase the capacity an shear. The glue used is existing concrete and act in an integrate member during service the of the

Repairing the distress due to torsional Shear (in beams)

I. Technique of Bonding Steel plates
   The steel plates 2 to 3 mm thick equal to the depth / width of the beam is glued on all sides of the member to increase its capacity in torsion taking care to see that the glue is compatible and acts in an integral manner during service life of the member
II. Technique of ferrcement Jacketing
   A ferrocement Jacket is provided all round the member, using weld mesh and chicken mesh reinforcement and cement

Technique for repairing axially loaded members

Concrete members

Jacketing techniques for increasing more sides is resorted to depending on the circumstances.

<u>Masonry members</u>

Caging with steel

A steel caging is prepared and made to surround the existing masonry so that lateral expansion when it is loaded in compression. The confinement of masonry will steel cage increases its capacity and ductility.

Jacketing with concrete

If the circumstance permit the existing masonry columns is made to act in core, by providing concrete Jacketing with concrete

If the circumstances permit the existing masonry columns is made to act core, by providing concrete Jacketing (with reinforcement), which will enhance the capacity of the masonry column.

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Lining / Jacketing with ferrocement

The confinement of masonry is achieved by providing lining / Jacketing with assessment on the outer skin of masonry clement which will enhance the capacity of the masonry column. This will facilitate decrease finish on the treat masonry column.

3. Explain in detail about Chemical disruption on concrete.

Three examples have been picked to demonstrate the types of problems that can arise in dams affected by alkali-aggregate reaction and to show ways in which remedial works can be approached.

Center Hill dam in Tennessee, USA, has a long history of operational problems appearing as leaking horizontal joints, as binding of spillway gates and as damage to the mechanisms for operating the gates. The dam consists of a 421 m long concrete gravity section on the right side of the valley and a 5237 m long earth fill embankment on the left side. The layout of the concrete section is shown diagrammatically in Fig.8.9. The spillway is controlled by eight tainted gates, each 50 ft (15.2m) wide, and is traversed by a highway bridge which consists of simply-supported spans of steel girders and concrete deck.

From the first filling in 1945 up till 1967, there were no serious deficiencies noted. In 1967, some horizontal lift joints near the centre of the spillway and near the crest were found to be leaking excessively. The leaks fwre put down to poor construction procedures and the joints were reinforced with anchors/bars. In 1974 several of the fixed supports of the bridge were found to be tilted and were reset. More leading joints appeared between 1975 and 1980 and in 1980 a gate jammed in the raised position. It was not until 1983, after excessive joint movement in the bridge spans, buckling of torque shafts for the gates, buckling of electrical conduits, and severe binding of the end gates, that major investigations were undertaken. It was concluded from the observations, tests and instrumentation data that the concrete was experiencing an alkali carbonate rock reaction. The expansion resulting from this reaction was causing the structure to grow and to move into the spillway opening. In 1984, the total spillway opening was 53.3 mm short of the design distance and the end gate bays (Nos 1 and 8)

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were both short of design distance by 27.2 mm at the level of the top of the dam. The right side of gate bay No 1 was leaning 47.6 mm into the opening and the left side of bay No 8 was leaning by 23.8 mm, also into the opening. The operational deficiencies in the bridge were overcome by shortening the expansion joints. The problems with the gats were fixed by shortening the two end gates and by building out to vertical the gate sealing strips in the adjacent monoliths.

No other remedial work was undertaken and it was recognized that the structure, even after 40 years, may continue to grow and that further corrections may be needed. No conclusion could be drawn as to the stage reached in the expansion process or as to the potential for continued expansion.

Val de la Mare dam in Jersey. Channel Islands, is a mass concrete dam completed in 1962. The layout of the dam is shown in Fig. 8.10. In 1971, upstream movement of 6 to 13 mm was noticed in the crest walkway in some blocks, and darkening and damp patches, accompanied by surface cracking, were observed on the downstream faces of the same blocks. After an extensive investigation, lasting three years, it was confirmed that alkali-silica reaction was occurring and that some blocks were much more severely affected than other. It was concluded that, although the aggregate throughout the dam was somewhat reactive, the worst reaction was occurring in sections built in the course of a three-month period. During this period cement with unusually high alkali content was used.

5. Describe in detail about the weathering action on concrete.

Many bridges and parking structures in cold climates have been severely damaged by de-icing salt causing corrosion of reinforcement and requiring repair. The process is generally labour-intensive and costly as indicated in the following typical case. Camsley Lane Viaduct, in Cheshire, UK, is a six-spam structure over a main road and a railway. It was built in 1963 at a cost of £263 000 and 20 years later it became necessary to spend almost £200 000 on repairs to the piers and crossheads forming the supporting trestles. Extensive delaminating and cracking had leaked through from the

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deck. A survey of the worst affected areas showed that cover to reinforcement was less than that required by 1985 standards and that potentials indicated a high probability of active corrosion. Chlorides up to 5 per cent free chloride ion by weight of cement were found and even at depths up to 150 mm chloride contents of 1 to 2 per cent existed. Carbonation was found to be relatively low (3 to 5 mm).

As a first step in the repair process, the cause of the trouble was diverted by modifying the deck drainage system, re-waterproofing the verges and the central median and installing asphaltic joints over the piers. The trestle repairs were put out to tender with all quantities billed and repair materials and methods specified. The two concrete repair materials used were (*i*) a flow able concrete with 16 mm aggregate and containing a plasticizer and a shrinkage-compensating additive, to be cast against forms in heights up to 1.5m, and (*ii*) a patching mortar to be applied b rendering, for areas less than .01 m^2. Laboratory and field trials were carried out. The octagonal piers were repaired first and to avoid overstress only three faces were tackled at one time. The specified sequence was:

i. Break-out in areas of delamination to 20 mm behind reinforcement. (This dimension allowed the 16mm aggregate to penetrate). The area was extended as needed to expose 50 mm length of uncorroded steel, a requirement that significantly increased the amount of bread-out.
ii. Square up edges with a 10 mm cut to avoid feather edges to patches.
iii. Replace any reinforcement which had lost over 10 per cent of effective area.
iv. Grit-blast concrete and steel to expose coarse aggregate and to remove rust.
v. Coat all steel with an inhibiting primer if it would have less than 15 mm of cover after reinstatement.
vi. Erect form work to provide pour depth no greater than 1.5 m.
vii. Fully saturated repair areas. (Three hours were found to be adequate.)
viii. Mix and place concrete.

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As the reinforcement was very congested, small pneumatic hammers were used for breaking out the concrete. The only reinforcement that needed to be replaced was stirrups in the cross-head and this was done by hooking bars around the top and bottom corner bars. Two types of formwork were used on the piers. The simpler form consisted of plywood planks, strap-banded together, which was readily adapted to the variations in the existing sections. A rigid glass fibre form did not have this advantage and allowed grout loss.

Work on the cross-heads was limited by the fact that there were areas of repair which were directly under bearings. Load had to be transferred from the bearing by using jacking beams before bread-out was started. The break out was shaped so that air would not be trapped when the repair concrete was poured.

To maintain control of the ingredients, when many small pours were necessary, the repair material was supplied pre-mixed in 50 kg bags and only water had to be added at the site. Each batch was tested for flow and cube strength. As the work continued from summer to winter, the strength was specified at two different temperatures: at 20'C, 35 Mpa at 24 hours and 50 Mpa at 72 hours; at 5'C, 15 Mpa at 24 hours and 35 Mpa at 72 hours. The requirement of early strength at low temperature was included to allow rapid repairs, but in the event was not required. Formwork was left in place for 38 hours and after striping the repairs were sprayed with curing compound or wrapped in polythene sheeting until seven days old.

After repair, the trestles were coated with a water resisting compound, either a lilane or a quartz sand cement slurry mix. Because of the limitations on the extent of the break-out, it was not certain that all the chloride contamination had been removed, but the repairs ensured that leaking from the deck had been slowed down by reinstating the reinforcement in dense, highly alkaline concrete; the permeability of the existing concrete had been reduced by coating. Inspection of the repairs has continued.

The repairs outlined show all the essentials for this sort of work, which was carried out on this job with careful attention to the control of materials and procedures. There must, however, be some doubt about the effectiveness of coating reinforcement

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which is to finish with less than 15 m of cover. When a coat is applied, the part of the bar adjacent to the end of the coating may be in a more dangerous condition than it was before, since a local corrosion cell can be set up at this point. It would seem on this job that the necessary cover of more than 15 mm could have been provided at all repairs and this would, in our view, have been the preferred procedure. It is doubtful, also, whether the curing process used after the removal of the forms was effective or necessary. If any further curing was required it would have been better to have used water sprays.

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