B.E/B.Tech Degree Examination Nov/Dec 2014

Eight Semester/Civil Engineering

REPAIR AND REHABILITATION OF STRUCTURES

(Regulation 2008)

Time: Three Hours **Maximum: 100 marks**

ANSWER ALL QUESTION

PART-A (10 × 2 = 20 marks)

1. **Differentiate between the terms retrofitting and rehabilitation of structures?**

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

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

2. **Define the terms inspection and its need?**

The maintenance is based on the climatic conditions under consideration the year is divided in to the following period.

i) Pre-monsoon inspection
ii) Post monsoon inspection

3. **Mention any two effects due to temperature changes in structures?**

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.

4. **Write the need for emphasizing cover thickness for marine structures?**

- For selecting concrete cover for reinforcement in marine structures, consideration of the corrosion protection of steel bars is indispensable. Therefore, requirements for quality and thickness of concrete cover must be established so the concrete cover prevents chlorides, oxygen, water, etc., from

reaching reinforcement through the life of the structure. To insure good performance of concrete cover, the chloride penetration process should be understood.

5. Name any two special mortars for repair with applications?

- Many special admixtures are used normal concrete for repair works
  1. Air entrain agents
  2. Super plasticizes.
  3. Shrinkage reducing agents
  4. Viscosity modifying agents
  5. Retards
  6. Corrosion inhibiting admixtures.
  7. High performance cementitous

6. List any two properties of concrete chemicals?

- **Polymer concrete:** they are highly resistant to chemical attack, freeze and thaw. Permeability and absorption is almost zero.
- **Polymer impregnated concrete**: It is having cube crushing strengths in excess of 100N/mm2 irrespective of the strengths of the original concrete.

7. Mention the role of rust eliminations in concrete?

- Carbonation reduces the pH level in concrete and allows future deterioration of steel rebar. It has better chemical resistance, weather resistance. This coating has penetration through all the stratified rust layer, reactions and conversion of rust stabilization

8. Write any two applications of vacuum concrete?

- Vacuum process of concreting enables to meet this conflicting demand and this process helps a high workable concrete to get high strength.

9. Mention any two causes of low strength in concrete members?

i. Using low quality material

ii. Corrosion of steel members

10. Mention any two methods of making concrete structures leakage proof?

i. Conventional leak sealing methods

ii. Leak sealing by injecting techniques

PART-B

11. a) i) Discuss the procedure of assessment for evaluating a damaged structure

1. Visual or Physical inspection of damaged structure.
2. Preparation & documenting the damages.
3. Collection of samples & carrying out tests both in situ & laboratory.
4. Studying the documents including structural aspects.
5. Estimation of loads acting on the structure.
6. Estimation of environmental effects including soil structure interaction.
7. Diagnosis
8. Taking preventive steps not to cause further damage
9. Retrospective analysis to get the diagnosis confirmed.
10. Assessment of structural adequacy.
11. Estimation of future use.
12. Remedial measures necessary to strengthen & repairing the structure.
13. Post repair evaluation through tests.
14. Load test to study the behavior
15. Choice of course of action for the restoration of structure.

Some Importance steps are

1. Visual inspection

- Any damages structure as a first step requires an extensive visual inspection followed by documentation of the details. A perusal of the documentation, supported by photographs will reveal all possible evidence of structural defects & damage.

2. Study of available documentation

- Study of available documentation will give some idea on the history of construction, original quality, analysis & design methods with assumption made & the type of materials used. It is unfortunate that the relevant details are not readily available in many cases. A comparison of adjacent buildings also helps in a proper diagnosis.

3. Estimation of actual loads & environmental effects

- It is generally found that there is in majority of the cases the loads acting on a structure will be much different from the loads assumed in design calculations.

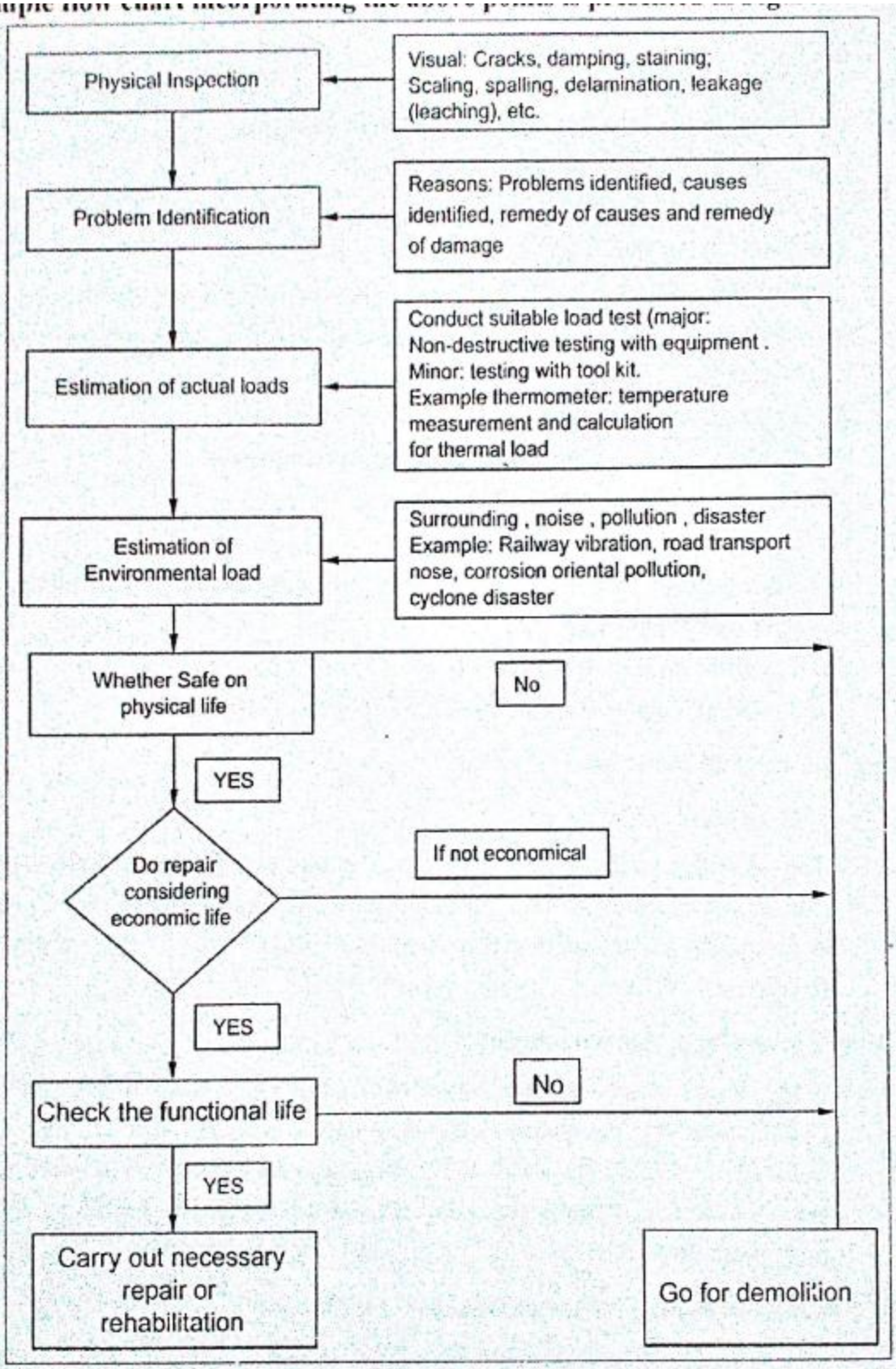


Fig. Steps in assessment procedure for evaluating damages in a structure

- Therefore cracking or any other damage may, sometimes be attributed to the fact that these loads or a certain load combinations were not considered in the analysis & design.
- Environment effects are likely to be different from those assumed or not considered at the design stage.
- Effect of temperature changes or a hostile atmosphere would impose serviceability or durability problems. Environmental changes will result in undesirable effect in foundations.

4. Diagnosis

- In any investigation, diagnosis of the cause or causes of damage is of prime importance & is difficult too.
- A proper & reliable diagnosis can be made only by the conducting a systematic investigation using proven rest methods & experienced personnel (i.e. workers).

11. a) ii) Enumerate the various facts of maintenance of a concrete structure

i) Emergency Maintenance

Necessitated by unforeseen break down drainage or damage caused by natural calamity like fire, floods, cyclone, earthquake etc.

ii) Conditions Based Maintenance

Work initiated after due to inspections

iii) Fixed Time Maintenance

Activities repeated at predetermined intervals of time.

iv) Preventive Maintenance

This is intended to preserve by preventing failure & detecting incipient faulty. (Work is done before failure)

v) Opportunity Maintenance

Work done as & when possible within the limits of operation demand.

vi) Day by Day care Maintenance

vii) Shut down Maintenance

Through overhaul & maintenance after closing a facility.

viii) Improvement Plans

This is essentially maintenance operation wherein the links in the original construction are either replaced by new parts or strengthened.

b) Discuss the various causes of deterioration of concrete structure mentioning their effects / symptoms.

Causes of Deterioration: (Concrete Structures)

1. Design & construction flaws
2. Environmental effects
3. Poor quality material used
4. Quality of supervision
5. Deterioration due to corrosion

1. Design& Construction Flaws

Design of concrete structures governs the performance of concrete structures. Well designed & detailed concrete structure will show less deterioration in comparison with poorly & detailed concrete, in the similar condition the beam-column joints are particularly prone to defective concrete, if dealing & 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.

2. Environmental Effects

Micro–cracks present in the concrete are the source of ingress of moisture & atmospheric carbon di-oxide into the concrete with attack reinforcement & react with various ingredients of concrete. In aggressive environment concrete structures will deteriorate faster & strength life of concrete structures will be severely reduced.

3. Poor Material Used

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

4. 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 & honey combed concrete, whereas excess vibration may cause segregation.

5. Deterioration Due To Corrosion

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

12 a) i) Define the term quality assurance and mention its significance for concrete construction

- A quality assurance scheme is a management system which increases confidence that a material, product or service will confirm to specified requirements. It outlines the commitments, polices, designated responsibilities & requirements of the owner.
- These are then implemented through quality assurance programs to provide a means of controlling, to pre-determined requirements, those activities which influence quality.

Need For Quality Assurance

- All involved with the construction & use of a concrete structure are concerned that the quality necessary to give good performance & appearance throughout its intended life is attained.
- The client requires it in promoting his next engineering scheme.
- The designer depends on it for his reputation & professional satisfaction.
- The material producer in influenced by the quality of work in his future sales.
- The building contractor also relies on it to promote his organization in procuring future contracts, but his task is often considerably by the problems of time scheduling & costs.
- The owner is particularly influenced in trouble-free use & low maintenance costs of such a structure of good appearance. It would be seen to follow

therefore that since all responsible parties gain by quality it should be automatically achieved. Yet this is not so & a considerable positive effort must be employed to achieve it.

- This effort can best be expended by instituting a quality assurance scheme which involves each of the above parties.
- In order to ensure that the frequency of faults in new constructions is minimized any potential faults and their underlying causes must first recognized

12. a. (ii) Write a note on permeability of concrete with influencing factors and methods of control.

- Since concrete is a permeable and porous nature, the liquid and gases can move inside the concrete and is called "Permeability i.e., 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. Therefore the gel pores don't contribute to the 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, kiben used up to about 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).

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 porous 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 capillary cavities depends on the W/c ratio. This is one of the main factors contributing or influencing permeability of concrete.

b) i) Define the term corrosion and discuss its types on rebar in concrete with influencing factors.

ii) Give a note on the strength property of concrete with factors influencing it.

Refer Unit II Page 2.14

13) a) Enumerate the procedure of manufacture, properties and its uses of 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

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

- Physical propertied have been found and large improvements in water 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 an after 24hrs of most (cooling) curing, the specimen is dried in heating cabinet for 24 hrs at 121°C. Then the dried specimen is placed in a container of molten sulphur at 121 °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.

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

13.b)Discuss the procedure of manufacture, properties and uses of fiber reinforced concrete

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers – each of which lend varying properties to the concrete. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities.

(*a*) Effect of fibers in concrete

Fibers are usually used in concrete to control cracking due to plastic shrinkage and to drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact–, abrasion–, and shatter–resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment–resisting or structural steel reinforcement. Indeed, some fibers actually reduce the strength of concrete.

(*b*) Benefits

Polypropylene and Nylon fibers can:

- Improve mix cohesion, improving pump ability over long distances
- Improve freeze-thaw resistance
- Improve resistance to explosive spalling in case of a severe fire
- Improve impact resistance
- Increase resistance to plastic shrinkage during curing

Steel fibers can:

- Improve structural strength
- Reduce steel reinforcement requirements
- Improve ductility
- Reduce crack widths and control the crack widths tightly, thus improving durability
- Improve impact– and abrasion–resistance
- Improve freeze-thaw resistance

Blends of both steel and polymeric fibers are often used in construction projects in order to combine the benefits of both products; structural improvements provided by steel fibers and the resistance to explosive spalling and plastic shrinkage improvements provided by polymeric fibers.

In certain specific circumstances, steel fiber can entirely replace traditional steel reinforcement bar ("rebar") in reinforced concrete. This is most common in industrial flooring but also in some other precasting applications. Typically, these are corroborated with laboratory testing to confirm that performance requirements are met. Care should be taken to ensure that local design code requirements are also met, which may impose minimum quantities of steel reinforcement within the concrete. There are increasing numbers of tunneling projects using precast lining segments reinforced only with steel fibers.

FRC increasingly used on account of the advantages of increased static & dynamic tensile strength, energy absorbing characteristic and better fatigue strength.

The uniform dispersion of fibers throughout the concrete provides isotropic properties not common to conventionally reinforced concrete

`14) a) i) Define underpinning and discuss the procedure of underpinning done for structures.

In construction, underpinning is the process of strengthening and stabilizing the foundation of an existing building or other structure.

Underpinning may be necessary for a variety of reasons:

- The original foundation is simply not strong or stable enough.
- The usage of the structure has changed.
- The properties of the soil supporting the foundation may have changed (possibly through subsidence) or were mischaracterized during design.
- The construction of nearby structures necessitates the excavation of soil supporting existing foundations.
- It is more economical, due to land price or otherwise, to work on the present structure's foundation than to build a new one.

Underpinning is accomplished by extending the foundation in depth or in breadth so it either rests on a more supportive soil stratum or distributes its load across a greater

area. Use of micro piles and jet grouting are common methods in underpinning. An alternative to underpinning is the strengthening of the soil by the introduction of a grout. All of these processes are generally expensive and elaborate.

Underpinning may be necessary where P class (problem) soils in certain areas of the site are encountered.

Through semantic change the word underpinning has evolved to encompass all abstract concepts that serve as a foundation.

Mass Concrete Underpinning

Traditional underpinning,' the mass concrete underpinning method is nearly 100 years in age, and the protocol has not changed since. This underpinning method strengthens an existing structure's foundation by digging boxes by hand underneath and sequentially pouring concrete in a strategic order. The final result is basically a foundation built underneath the existing foundation. This underpinning method is generally applied when the existing foundation is at a shallow depth, however, the method still works very well even at fifty feet deep. The method has not changed since its inception with its use of utilitarian tools such as shovels and post whole diggers. Heavy machinery is not called for in this method due to the tight nature of the boxes being dug. There are several advantages to using this method of underpinning including the simplicity of the engineering, the low cost of labor to produce the result, and the continuity of the structure's uses during construction.

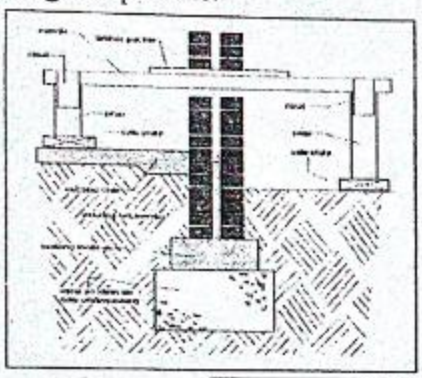
Beam and base underpinning

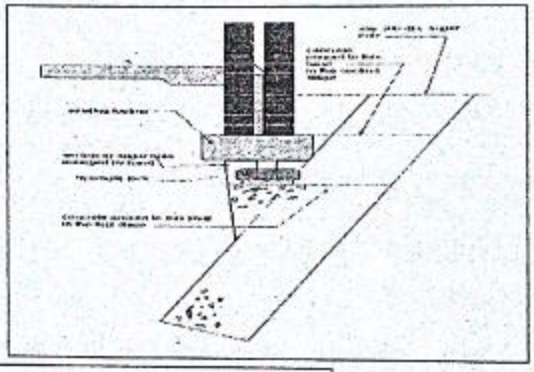
The beam and base method of underpinning is a more technically advanced adaptation of traditional mass concrete underpinning. A reinforced concrete beam is constructed below, above or in replacement of the existing footing. The beam then transfers the load of the building to mass concrete bases, which are constructed at designed strategic locations. Base sizes and depths are dependent upon the prevailing ground conditions. Beam design is dependent upon the configuration of the building and the applied loads. Anti-heave precautions are often incorporated in schemes where potential expansion of clay soils may occur

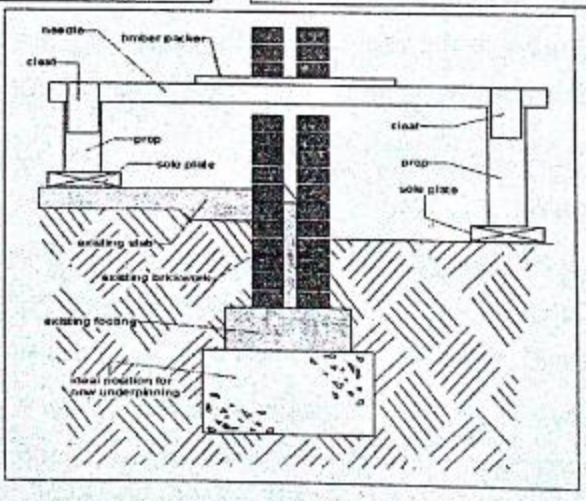
Mini-piled underpinning

Mini-piles have the greatest value where ground conditions are very variable, where access is restrictive, where environmental pollution aspects are significant, and where

structural movements in service must be minimal. Mini-piled underpinning is generally used when the loads from the foundations need to be transferred to stable soils at considerable depths - usually in excess of 5.0 meters. Mini-piles may either be augured or driven steel cased, and are normally between 150mm and 300mm in diameter. Structural engineers will use rigs which are specifically designed to operate in environments with restricted headroom and limited space, and can gain access through a regular domestic doorway. They are capable of constructing piles to depths of up to 15 meters. The technique of minipiling was first applied in Italy in 1952, and has gone through a plethora of different names, reflecting worldwide acceptance and expiration of the original patents.







14.(a) ii) Write a note on engineered demolition techniques for dilapidated structures.

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.

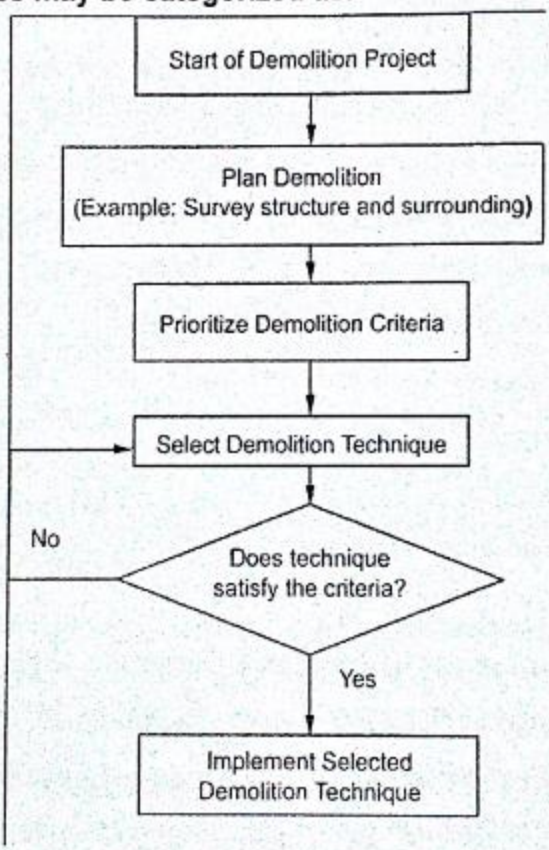
Normally, the demolition contractor is able to adopt a method of work which:-

- 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.

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

  A. Balling Machine

  B. Hydraulic Pusher Arm

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-expiosive "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.

b) Enumerate the various methods of corrosion protection done to RC structures.

- 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:
- 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 program.

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 prc stressing 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.
- 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 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 counter current 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 buried 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. All any two corrosion protection methods.

15) a) Consider a RC structure in a marine environment, discuss the possible types of distress likely to affect the structure and suggest suitable remedy/ protection for the structures.

Refer Unit V

b) Discuss the various rehabilitation measures to be adopted to overcome the distress due to excessive deflection and cracking of structure.

The concrete structure has joints and crack. Hence cracks and joint sealers are very important in concrete structure. The crack sealers should ensure the structure integrity and service-ability.

They should also provide protection from penetration or ingress of harmful liquids and gases.

Stitching of concrete

The process of stitching of cracks is adopted when the tensile strength of the member is to be restored across the major cracks.

Stitching does not close the crack; it only prevents it from further spreading. Stitching tends to stiffen the structure.

Repair by jacketing

This method of repair is useful for the compression member a column, piers etc. In this case a durable material is fastened over the exiting concrete and the gap is filled with a grout.

The grout filled provides the needed performance characteristics thus jacketing restores or increases the section of an existing member by encasement in a new concrete.

★✦★