Maintenance And Repair Of Buildings.

What is maintenance ?

- It is the work undertaken to restore or improve every facility in every part of a building , its services and surroundings to currently accepted standards and to sustain utility values of the facility.

Objectives Of Maintenance :

- To preserve in good condition buildings and services.
- When deterioration occurs due to any reason it is inevitable to restore it to its original standard.
- To make improvements whenever required.
- To sustain utility value.

A good maintenance team has to ensure

1. **Safety**
2. **Efficiency**
3. **Reliability**

Maintenance operations have many facets such as :

1. Condition based maintenance :
   - It is the work initiated after inspection.
2. Fixed time maintenance :
   - Activities repeated at predetermined intervals.
3. Preventative maintenance :
   - This is intended to preserve by preventing failure and detecting incipient faults.
4. Opportunity maintenance :
   - Work done as and when possible within the limits of operational demand.
5. Day to day maintenance :
   - Its involves maintenance that has to be performed daily.
6. Shutdown maintenance :
   - Through overhaul and maintenance after closing.

Maintenance operations have many facets such as :

- **Emergency maintenance** : Necessitated by unforeseen breakdown damage or a damage caused by natural calamity like earthquakes, floods ,etc.

Before

Before

After

After

Examples of some common maintenance works in a building are as follows : -

- **Maintenance Survey for water supply and sanitary system :**

  In case of water supply and sanitary system , periodic surveys are necessary to observe how the system is functioning. Normally inspection should start from the top and proceeded downwards. Drawings which indicate various services as laid should be obtained to facilitate survey.

Maintenance of Electrical Installations :

The electrical installation is made safe by getting it installed and maintained through licensed persons. Its necessary that the installation is checked periodically and a proper record of such work is maintained. Recommended periodicity of checking is as follows :

1. Earthing test - Once a year
2. Insulation - Twice a year
3. Polarity - Once in five years.

Maintenance of Elevators

In multistoreyed buildings vertical transportation is an essential service. The vertical transportation is effected by lifts which could be of various types such as passenger lifts , goods lifts special lifts in hospitals , etc. Without adequate vertical transportation the entire activity in the multistoreyed building would come to a standstill.

Lift maintenance should cover :

1. All mechanical equipments such as sheaves , buffers door closers , floor selectors , limit switches , door hangers ,etc.
2. Interlocks – mechanical fastenings to the base and latching head is locked securely when door is closed. The electrical contact should not get made unless the door is fully closed and locked.
3. Hoist and governor ropes for wear and rust
4. Travelling cables – Make sure that they are properly hung and outer wrapping is not worn out to avoid short circuit.
5. Rails – Alignment , tightness of all plates brackets.

Maintenance of walls to avoid efflorescence

Efflorescence is caused due to entry of moisture into the brickwork and soaking it to saturation. Once the moisture has entered it moves upward due to capillary action; reasons for entry of moisture are-

- Porous nature of structure
- Cracks in the wall
- Existing voids left due to bad workmanship
- Small trees and plants in the wall
- Nonexistence of damp proof course or failure of DPC

EFFECTS OF EFFLORESCENCE

- Dry rot of woodwork
- Disintegration of masonry
- Damage to furniture
- Crumbling of plaster

STEPS TO AVOID EFFLOROSCENCE

Eradication of efflorescence is quite difficult and it is often termed as cancer of buildings .The first step to check efflorescence is to check the ingress of moisture in buildings if there is no failure of DPC efflorescence can be checked easily .

- Step one- ingress of water is checked
- Step two- plaster is removed both inside and outside and is left to dry
- Step three- voids in the wall are filled
- Step four- walls are washed with tamarind water to remove stains
- Step five- walls are replastered with cement mortar not leaner than 1:4 and a water proofing admixtures

What is repair ?

It is defined as the process of restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition or state.

Some common types of repairs are as follows :

1. Patching up of defects such as cracks and fall of plaster.
2. Repairing doors, windows, replacement of glass panes.
3. Checking and repairing electric wiring.
4. Checking and repairing gas pipes, water pipes and plumbing services.
5. Re-building non-structural walls, smoke chimneys, boundary walls, etc.
6. Re-plastering of walls as required.
7. Rearranging disturbed roofing tiles.
8. Relaying cracked flooring at ground level.
9. Redecoration — whitewashing, painting, etc.

Examples of some common repair works in a building are as follows : -

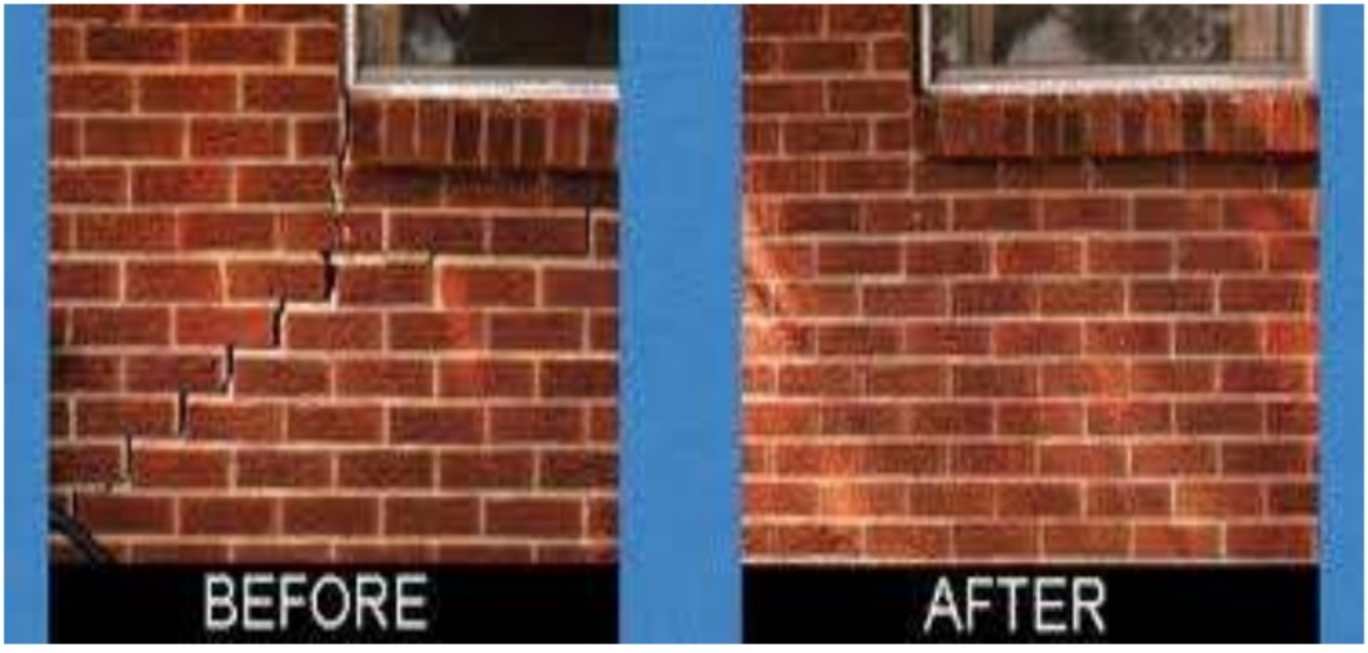
REPAIR OF CRACKS IN WALLS

Cracks are signs of distress in structural and non-structural members caused due to separation of joints , development of fissures , shearing, separation of members built with different materials . Cracks may be at different locations like – vertical, horizontal, inclined ,separation at the roof level just below the junction of RCC slab and masonry wall , in parapet , at junctions of RCC columns etc. They may be wide narrow or hairline and can be of varying depths. They are classified broadly as structural and non structural cracks; with structural cracks forming due to incorrect design faulty construction, and non structural cracks forming due to internal stresses .

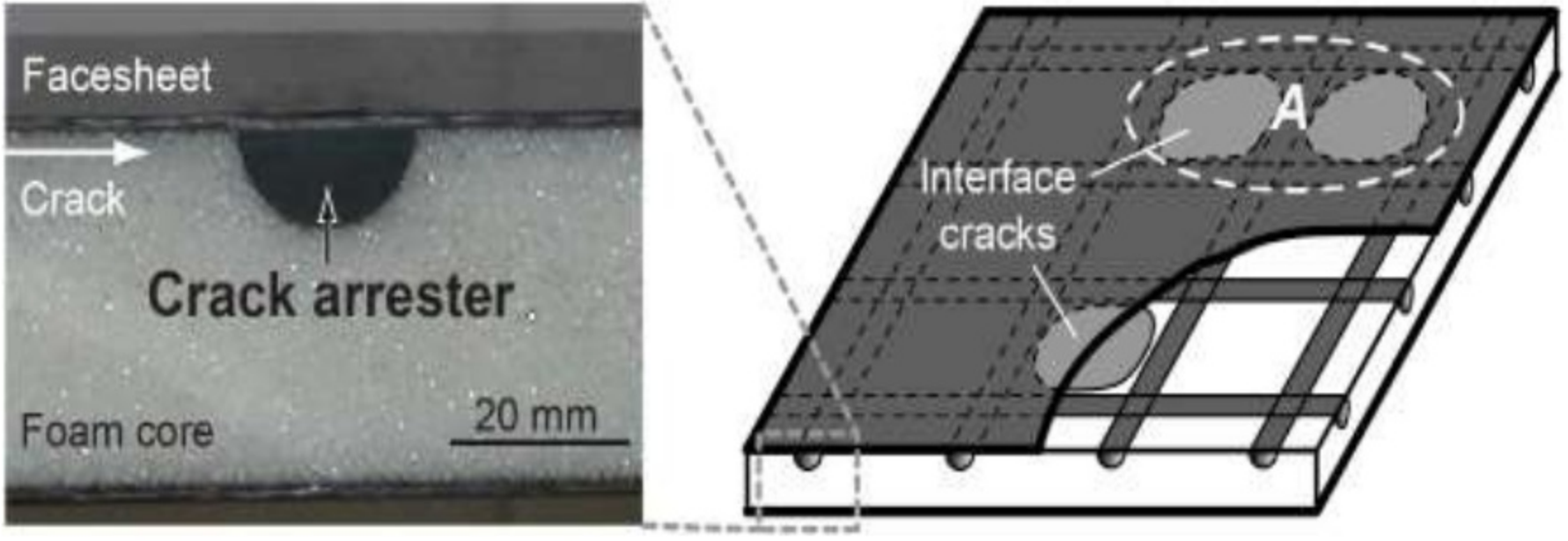
DIFFERENT METHODS OF REPAIR OF CRACKS

1. Non structural or surface cracks -They do not require elaborate measures as they prevail on the surface only. After removal of the rendering, cracks if observed in masonry are cut v shaped upto a depth of 12-30 mm and filled with cement mortar 1:4and then the surface is replastered.

2. Very heavy cracks – If there are very heavy cracks all over the external load bearing wall along with signs of settlement, the wall is considered beyond repair and needs replacement. The load carried by the wall is supported on props , the old wall is demolished part by part and then rebuilt either in brickwork or suitable RCC framework.



3. RCC band (crack arrestor) – an active crack in progress may be arrested by providing an RCC band along the line of crack. RCC band helps in checking further cracking and provide adequate strengthened sections for brickwork. The brickwork has to be opened on either side of the crack upto a depth of 100 to 150mm or one third the thickness of the wall ; the exposed surface is roughened and cleaned , the reinforcement mesh is placed and filled with good concrete . The procedure is repeated on both sides of the wall



3. Cracks over arch openings – In old buildings we can see cracks over arch openings . It indicates that the arch has reached the limit of its load transfer mechanism. If the cracks are not severe they are repaired by driving metallic wedges from below.

4. Stitching – stitching is done to repair cracks of brickwork.

5. Cracks observed at junctions of two different materials RCC columns and masonry walls
   a. RCC columns and masonry wall - cracks appear due to difference in thermal coefficients of the two materials and can be prevented by inserting GI butterfly ties between RCC column and brickwork. The ties are provided at alternate layers of brickwork.
   b. In buildings having this problem and water entering from the crack and causing dampness of thewall , the external plaster on the outer face 100mm on either side of the crack may be taken out and replastered after fixing chicken wire mesh over the crack. In all cases of junctions rendering should be one after fixing chicken wire mesh.

REPAIR OF PLASTERING WORKS

DEFECTS WHICH OCCUR IN PLASTERING WORKS-

- Blistering- this occurs due local relative expansion of the finishing coat
- Bond failure or loss of adhesion – this causes hollow patches , flaking of top coats , bulging or peeling of areas.
- Cracking – caused due to structural movement , exposure to direct sun or shrinkage

Crazing – caused due to tensile stress

Efflorescence – caused due to presence of salts in masonry which dissolve in moisture entering in it

Irregularity of surface - caused due to faulty workmanship.

Recurrent surface dampness – due to presence of deliquescent salts in sands used in plastering

CRACKS IN RENDERING AND PLASTER ALONGWITH REMEDIAL MEASURES

1. Shrinkage cracks – shrinkage cracks in rendering plaster occur after the first dry spell . They may occur due to lack of bond with the masonry surface and is identified by tapping the affected surface which would produce a hollow sound. Crack due to sulphate action occur after 2 to 3 years from construction. Remedial measure would be to remove the plaster and renewing it after raking the joints 10 mm deep.

2. Cracks around door frames – this type of cracks occur due to shrinkage of wooden frames or due to loose fixing of door frames . Loose fixing causes vibration of frame and cracks develop at the junction . Cracks may also develop when the timber of the frame is not properly seasoned. As a preventative measure the timber should be properly seasoned and the frame should be rigidly fixed. As a remedial measure the junction of frame and masonry should be concealed by architraves.

REPAIR OF CRACKS IN RCC MEMBER OF A STRUCTURE

NATURE AND TYPE OF CRACKS

- Random cracks in structure exposed to weather –these cracks occur after many years of construction maybe 15to 20 years ; they are likely to be caused due to shrinkage from carbonation of concrete.
- Straight cracks in columns, beams and slabs – these cracks are parallel to reinforcement along with spalling of cover . Exposure of reinforcement may occur at places
- Straight cracks in RCC sun shades and balconies – these cracks are straight and along the length occurring at intervals of 3 to 5 metres
- They are due to shrinkage along with thermal action
- Straight cracks in RCC slabs of long open verandahs – these cracks may occur at intervals of 6 to 8 metres parallel to the reinforcement. They are caused due to shrinkage and thermal contraction. These cracks are wider in winters

INSPECTION OF THE CRACKS

Close inspection of the cracks is necessary to ascertain the nature of the damage. This may be done by sophisticated instruments or by visual comparing.

Cracks are defined according to the width of separation :

Fine – width less than 0.1mm

Thin – width 0.1 to 0.3 mm

Medium – width 0.3 to 0.7 mm

Wide – width 0.7 to 2.0 mm

Very wide – width >2.0 mm

REPAIRS FOR STRENGTHENING OF RCC STRUCTURAL MEMBERS

1. Cracks in the RCC member – when we see cracks due to excessive bending moment , the load causing the cracks is released as far as possible and the member is strengthened by adding reinforcing steel with proper key and bonding with the old member is done.

2. Cracks due to shear – these cracks are at 45 deg. To the axis of the member and are corrected by adding diagonal shear reinforcement in the form of stitching dowels

3. Cracks at support or at midspan bottom – they occur due to insufficient steel or insufficient provision of displacement of steel. They are corrected by addition of steel as required. The ends of the added steel are bent and inserted in the member by drilling.

4. Pressure grouting - this method is used when the concrete has become porous but has not decayed. To check this, holes are drilled in the member as per requirement and cement slurry and/or chemicals are grouted under pressure and forced in the holes.

5. Cracks in foundation due to settlement – these when detected is often beyond repair , the foundation has to be redesigned with a wider base and/or the foundation has to be taken on soil having adequate bearing capacity. Cement slurry grouting is often used to increase the bearing capacity of soil.

6.Load relieving techniques – the member can be prestressed externally by placing prestressing wires on both sides and then inducing tension.

Content

Importance of Maintenance
Meaning of maintenance
Objective or Necessity of maintenance
Factors influencing the repair and maintenance

Importance of Maintenance –

- All the building components start deterioration after certain period due to action of various natural forces like rain, sunlight, wind etc.
- Sometime there may be problem in the buildings due to use of poor construction material, due to poor workmanship or faulty design etc.
- In such situations, repairs of a building becomes and inevitable process otherwise there defects/ problems in the building will go on multiplying and will reach a point of no return.
- Also the regular maintenance of a building is required to keep it suitable for use and extend the useful life of the building. Hence regular maintenance is needed for the structure / buildings right form the moment it is put to use

Meaning of maintenance –

- The British Standard has defined maintenance as "The Combination of all technical and administrative actions carried out to retain an item in order or to restore it to a state in which it can perform its required function."
- The committee on Maintenance under Government of India defined maintenance as "Building maintenance is work undertaken to keep restore or improve every facility i.e. every part of a building, its service and surroundings to a currently acceptable standard and to sustain the utility and value of the facility."
- Hence in simple terms "Maintenance is defined as the work undertaken to keep the structure in good condition so as to enable it to carry out all those function smoothly for which it has been constructed."

Objective or Necessity of maintenance –

1. To keep the structure in good appearance and working condition.
2. To prevent damages, deterioration and decay of structure cause due to adverse effects of weathering agencies.
3. To make improvements by rectifying defects in the structure caused due to use of poor building materials or poor workmanship.
4. To strengthen the structure to restore them back to their original standards.
5. To improve the facilities depending upon the development that is taking place in the concerned field
6. To sustain the utility value
7. To enhance serviceability of the structures
8. To avoid crisis maintenance by regular and planned maintenance programme.

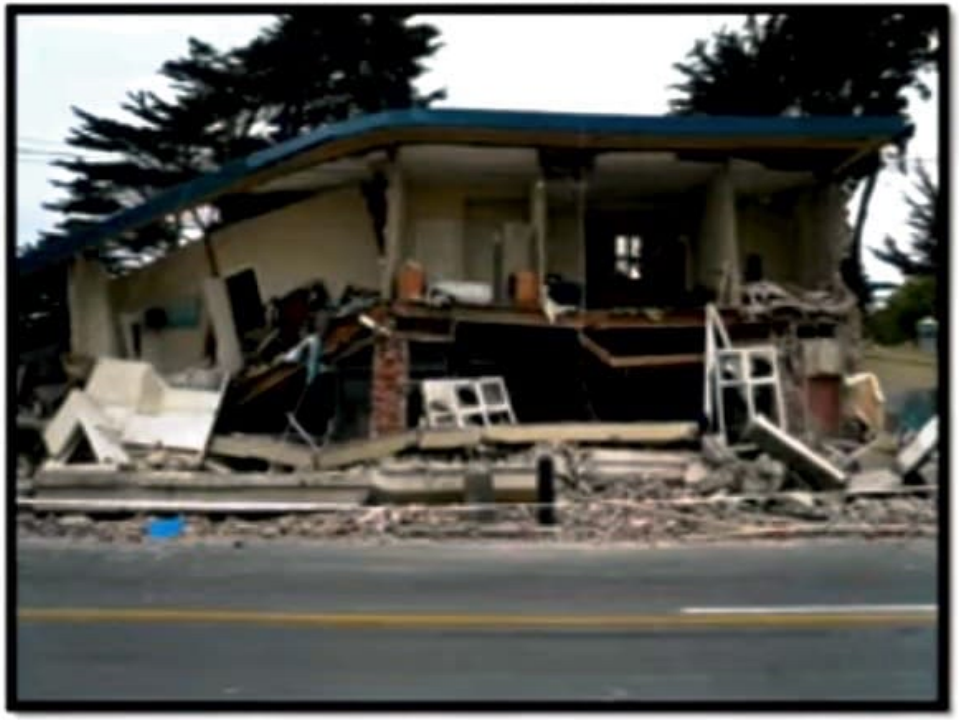
Factors influencing the repair and maintenance –

1. Age of property –

- It is most important to access the age of the structure before planning the maintenance of a structure.
- The remaining useful life of building will only justify the amount of capital spent for the repair and maintenance of building.

2. Total costs involved –

- Total costs involved for the repair and maintenance of a structure is a major factor which influence the decision to undertake maintenance operation.
- The cost of maintenance should be worked out before starting the maintenance work of a structure. It include expense on the material and labour required



3. Availability of resources –

- Maintenance of a structure can be taken up only when the availability of all the physical resources is ensured.
- The resources include material, equipments and labour.

4. Urgency of maintenance –

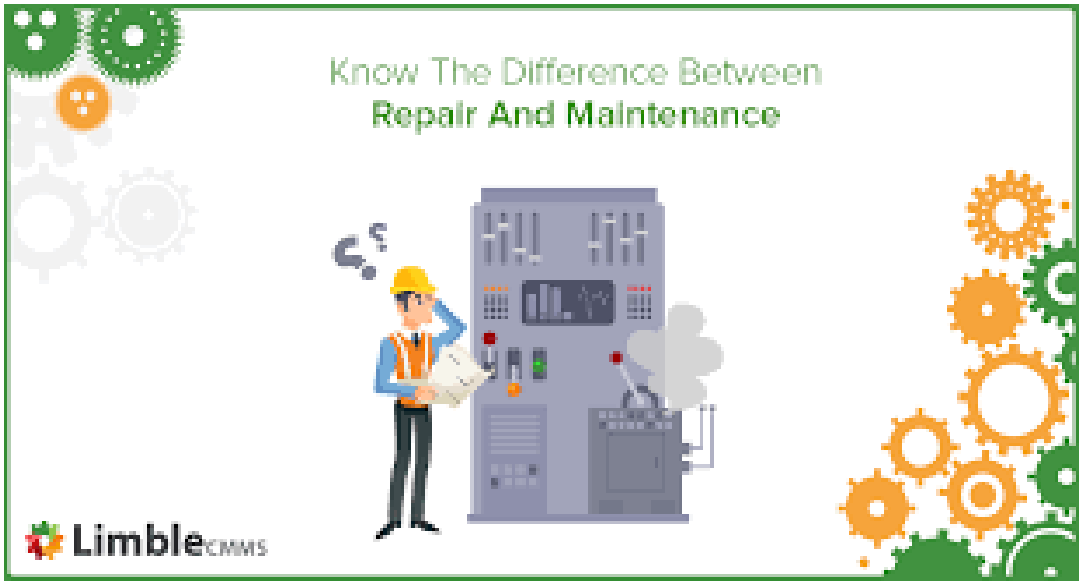
- An urgent maintenance work may be required for repair of services or repair of fittings / components. For urgent maintenance work, the cost will become of secondary importance.

5. Future use of the structure –

- The future use of the building must be considered before starting the maintenance operation.
- The extent of repair and timing of maintenance should be duly considered.

6. Social consideration –

- The following factors are also considered while planning the maintenance of building.
- The maintenance should be planned properly to minimize the nuisance.
- The maintenance work should be undertaken without disturbing the occupants or if possible it may be carried out when the building is unoccupied.
- Disturbances such as noise, dust, smell and the interruption of services should be bare minimum.



- **Repairs are restoration work for when something gets broken, damaged or stops working.**

- **Maintenance are routine activities meant to prevent damage and prolong the life of appliances, fixtures, and the property itself. Examples include regular cleaning of air-conditioning units, grease traps, repainting, and the likes. In these examples, nothing is broken nor damaged, but work is still done to slow down deterioration.**

- **In simple terms "*Maintenance* is defined as the work undertaken to keep the structure in good condition so as to enable it to carry out al those functions smoothly for which it has been constructed. "**

- **OBJECTIVES OF MAINTENANCE**
  or
- **NECESSITY OF MAINTENANCE**
  or
- **AIMS OF MAINTENANCE**

The main objectives of the maintenance of a structure are as follows:

1. To keep the structure in good appearance and working condition.
2. To prevent damages, deterioration and decay of structure caused due to adverse effects of weathering agencies.
3. To make improvements by rectifying defects in the structure caused due to use of poor building materials or poor workmanship.
4. To strengthen the structure to restore them back to their original standards.

5.To improve the facilities depending upon the development that is taking,place in the concerned field.

6. To sustain the utility value.
7. To enhance serviceability of the structures.
8. To avoid crisis maintenance by regular and planned maintenance-programme.

- **FACTORS INFLUENCING THE REPAIR AND MAINTENANCE**

The following are important factors which influence the decision to carry out repair and maintenance of structure:

1. Age of property
2. Total costs involved
3. Availability of resources
4. Urgency of maintenance
5. Future use of the structure
6. Social considerations.

1. Age of property: It is most important to assess the age of the structure n before planning the maintenance of a structure. The remaining useful life of building will only justify the amount of capital spent for the repair and maintenance of a building

2.Total costs involved: Total costs involved for the repair and maintenance of a structure is a major factor which influences the decision to undertake maintenance operation. The cost of maintenance should be worked out before starting the maintenance work of a structure. It includes expenses on the material and labour required.

3. Availability of resources : Maintenance of a structure can be taken up only when the availability of all the physical resources is ensured. The resources include materials, equipments and labour.

4. Urgency of maintenance : An urgent maintenance work may be required for repair of services or repair of fittings/ components. For urgent maintenance work, the cost will become of secondary importance.

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➢ CLASSIFICATION OF MAINTENANCE WORK

Maintenance work is broadly classified in the following categories:

1. Routine maintenance (fixed time interval maintenance)
2. Preventive maintenance
3. Remedial maintenance
4 Special maintenance

1. Routine maintenance : Routine maintenance may be defined as the maintenance activities undertaken at predetermined interval (periodically) to attend the defects or likely decay of the structure.

Following are the activities which fall under the routing maintenance:

1. Checking and repairing, if any, in water supply line.
2. Checking and repairing of leakage, if any, in soil pipes, Waste water pipes, and rain water pipes.
3. Cleaning of the water reservoirs periodically at intervals of not more than three months, both at ground and overhead.
4. Narrow hair cracks may be observed in the walls. These should be dug up and filled with cement mortar.) This would prevent further damage of the affected portion. These filled-up cracks should be kept under observation.
5. Plastering on the walls both internal and external and ceiling may show bulging or cracks, These areas must be checked thoroughly by beating with s a light wooden hammer. The portions emitting dull sound indicate a separation of the plaster from the surface. These portions should be taken out in regular shape and replastered with mortar of same proportion after raking out the brick joints and cleaning the surface.
6. Painting internal and external surfaces of building is essential for hygienic, protection of structure and aesthetic. The rendering on the surface protects the structure.
7. Painting of doors and windows is to be done periodically.
8. Plinth protection around the building need to be maintained properly. It will prevent any passage for the surface water to percolate to the foundation threatening its settlement and dampness on the walls.
9. The small plants on the walls and roofs of the building should not only be removed but also be uprooted and the place should be treated with copper sulphate solution or acid for permanent eradication.
10. The roof tops should be cleaned regularly otherwise dust and rubbish would block the outlets causing accumulation of rainwater on the roof, which ultimately would find way through the roof causing severe structural damage.

2. Preventive maintenance: Preventive maintenance may be defined as the in maintenance activities undertaken before the defects occur or damage developed the structure.

3. Remedial maintenance : Remedial maintenance may be defined as the

maintenance activities undertaken after the defects and damage have occurred in the structure.
Following steps are involved in the process of remedial maintenance:

1.Finding the defect or damage.
2.Ascertaining the possible causes of defect.
3. Evaluating the strengths of the existing structures.
4. Assessing the need/importance of the existing structure and financial viability of the maintenance work.
5.Selecting and implementing the procedure for the maintenance activity.

4. Special maintenance:Special maintenance may be defined as the maintenance activities performed under special conditions to rectify heavy damage to the structure.
It may include particular or complete renewal of floors, roofs, changing the joinery work etc.

Content

Deterioration

Factors causing deterioration

1. Human factors
2. Chemical factors
3. Environmental factors
4. Miscellaneous factors

Definition of Deterioration/Decay –

- In maintenance engineering, deterioration is defined as the gradual and continuous process of degeneration of a structure of its components which render it unusable.
- Deterioration or decay is the development of defects in a structure may be due to natural cause of ageing.
- If deterioration is not checked or is allowed to occur, decomposition of material results and replacement become the only solution.
- The rate of deterioration depends on the resisting capability of material.

Factors causing Deterioration –

- The deterioration of structure may be due to single or a combination of several factors.

1. Human factors
2. Chemical factors
3. Environmental factors
4. Miscellaneous factors

Human factors –

- Most of the deterioration of structures is due to human factors.

1. Use of poor construction materials
2. Poor workmanship during construction
3. Lack of knowledge about factors causing deterioration.
4. Failure to carry out routine maintenance.
5. Lack of supervision during construction.
6. Lack of awareness of maintenance need among the users.
7. Poor planning, budgeting and allocation of funds for maintenance work.
8. Blatant abuse of building, its fittings, finishing etc.

9. Having a casual approach towards repairs and a negative attitude of waiting until emergency measure are required.
10. Lack of proper cleaning resulting into formation of injurious material (alkaline and acidic) which attack the building components in contact.

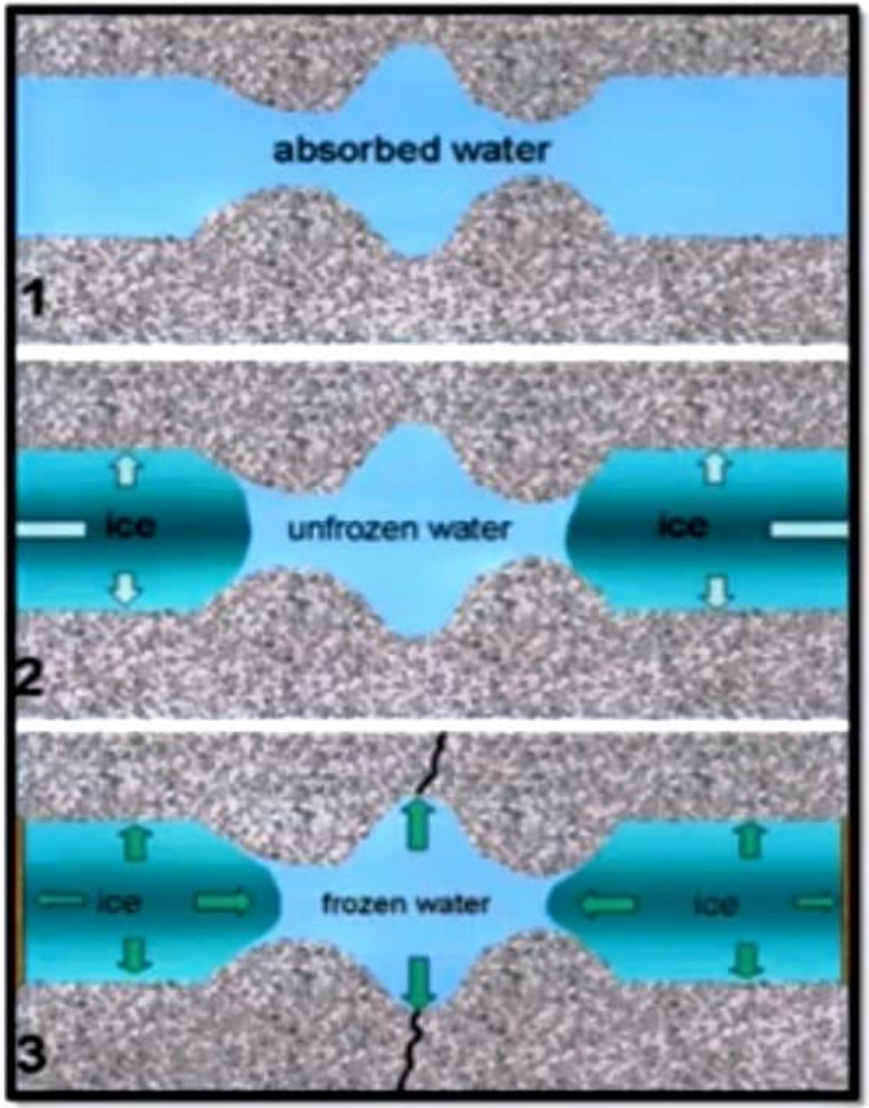
Chemical factors –

- Chemical reactions take place due to intersection of certain materials with surrounding environment.
- This leads to disintegration, softening or discoloration of materials or components.
- Corrosion is the result of chemical reaction of the material with air and water of the atmosphere.

Environmental factors –

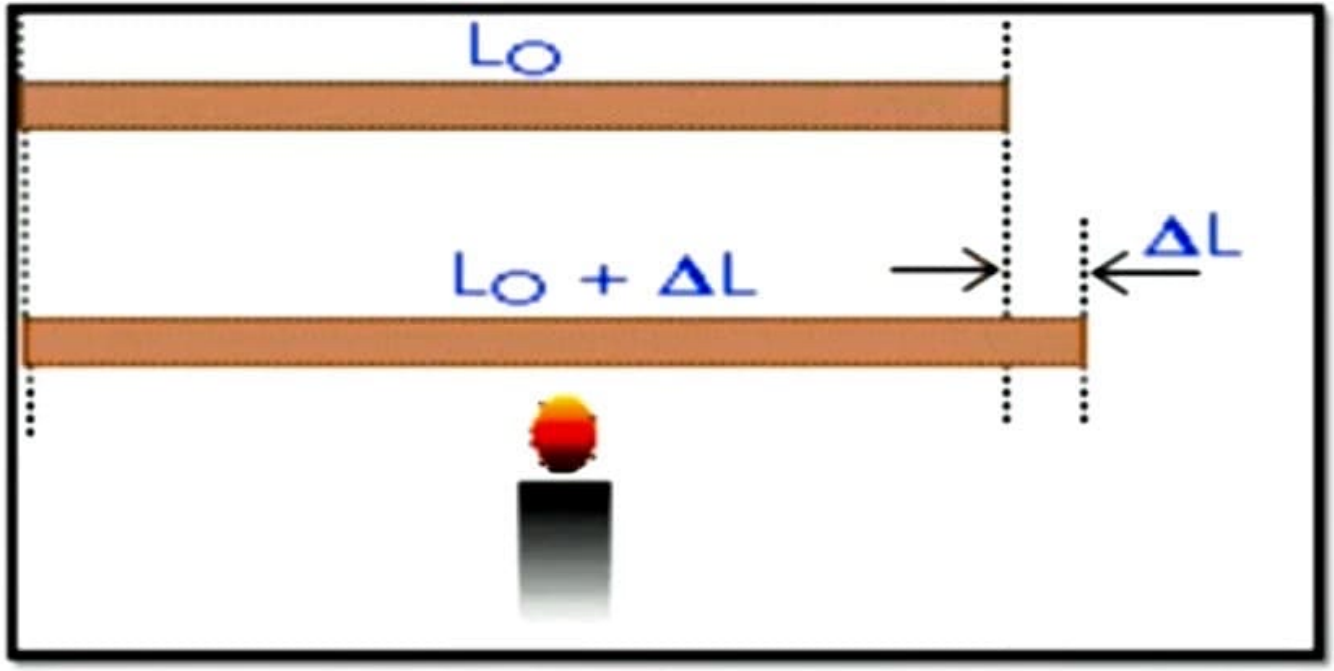
1. Atmospheric moisture –

- Atmospheric moisture is regarded as the principal agent causing deterioration of the structures.
- Moisture is always present in the atmosphere and when surface temperature falls, condensation occur.
- Water frozen in the pores of material can cause spalling of the surface, cracking or disintegration.



2. Temperature effects –

- Temperature changes cause temperature stresses in the materials of the structure. These stresses cause rupture and failure of the building material.

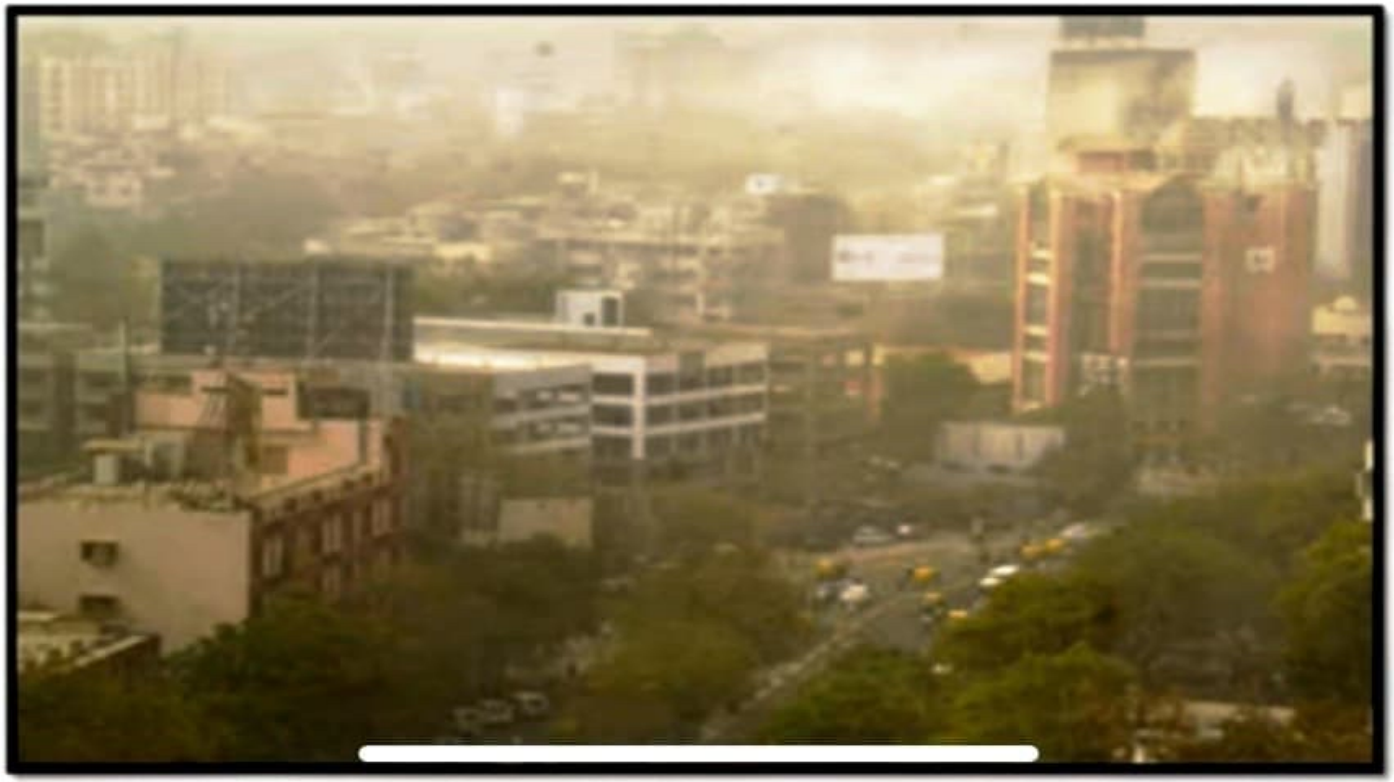


3. Gaseous pollutants of air –

- The ever increasing pollution also is the major source causing deterioration of structure.
- SO_2 is the most aggressive gaseous pollutant which causes corrosion of some metals and cause some stones to blister and spall.
- CO_2 also forms a weak acid, capable of slowly eroding limestone. The extent of carbonation in concrete has a marked influence on the corrosion rate of reinforcement.

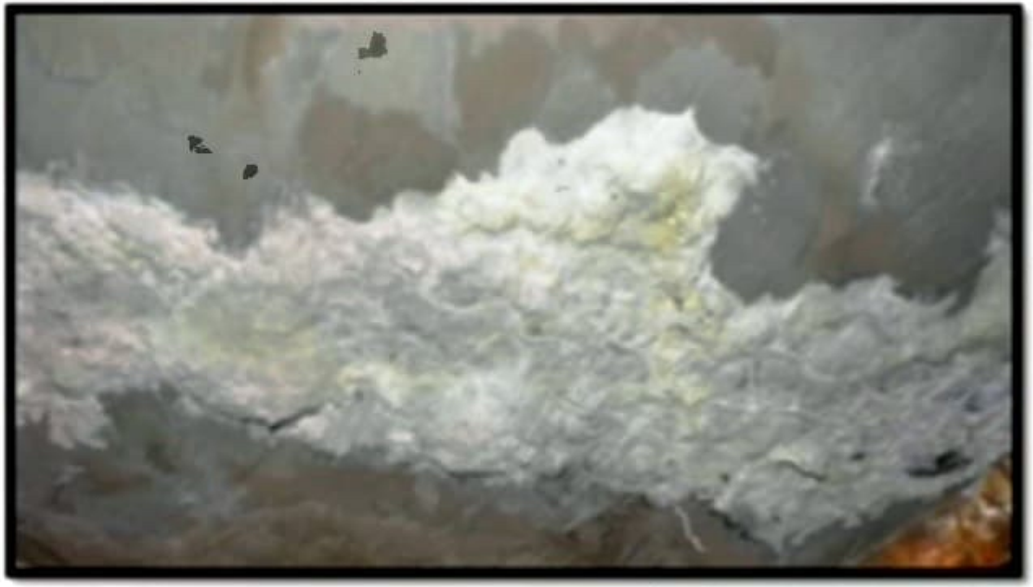
4. Solid contaminants –

- The dirt from the atmosphere also has adverse effect on the building. The dirt also contains some soluble salts.
- It absorbs water form the atmosphere and accelerates corrosion rate of metals and deterioration of some stone surface.



5. Ground water and salts –

- Salts present in the groundwater rise in solution by capillary action. On evaporation of water, salts remain deposit on the surface and damage the building.
- Usually it cause efflorescence and defacing of building surfaces and finishes.
- More seriously if magnesium sulphate is present in groundwater, disintegration of rendering and masonry surface can occur.
- Acidic ground water can cause disintegration of concrete.



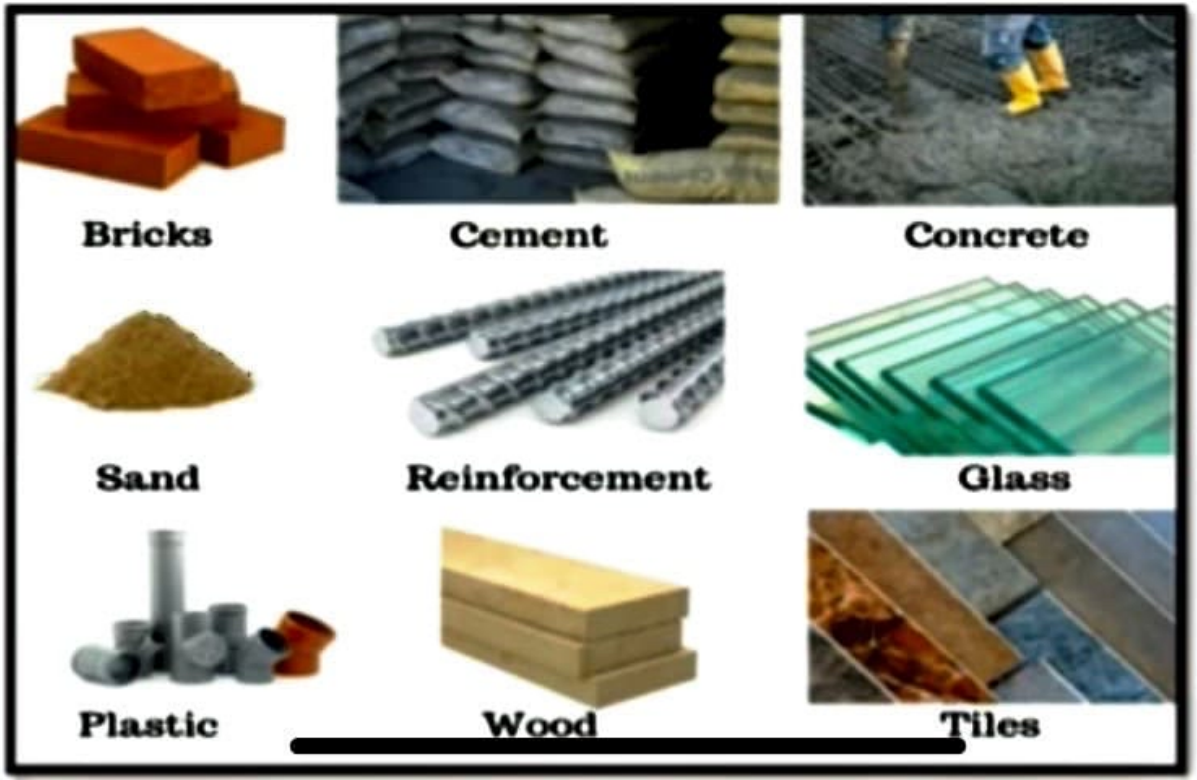
6. Biological agencies –

- Some construction materials get affected by biological agencies such as alge, moss, termites etc. The attack of termites on timber is very prominent.

7. Miscellaneous factors –

1. Poor construction material –

- Use of sub standard construction material, inadequate inspection of material, poor storage facilities at site for construction materials and inconsistent mixing of materials at site are factors responsible for deterioration of building at a later stage.



2. Poor design –

- Poor and faulty design leads to faster deterioration of the structure.

3. Poor workmanship –

- Failure to understand exactly the specification and drawing
- Lack of skilled labour
- Lack of supervision during construction
- Failure to replace the defective work noticed, if any.
- Over emphasis on quantity rather than quality of construction.

4. Misuse of building –

- It includes the use of building for which it has not been designed. Blatant misuse of building, its fittings, furnishing etc. may leads to deterioration of the building.

Content

Effects of deterioration on building material

1. Brick
2. Timber
3. Concrete
4. Metals
5. Paint
6. Plastic

Effect of various agencies of deterioration on different building materials

- It is necessary to understand the effect of various agencies causing deterioration of building material to take proper protection against these agencies.
- **The choice of building material is governed by –**

a. Ability to withstand the effect of climate
b. Ability to fulfill the designed function
c. Reaction with surrounding material
d. Ease of maintenance and replacement
e. Overall economic acceptability

1. Brick –

- Generally bricks have good durability. The most common effects of weathering on bricks are

a. Efflorescence (deposition of white powdery material causing disfigurement of bricks)
b. Spalling of the external surface
c. Change in appearance

2. Timber –

a. Timber decay as a result of destructive action of fungi (called dry rot) growing on it.
b. Dry rot requires a moisture content of about 20% and spreads very rapidly
c. Insects infection (beetles, termites) destroys timber used in building
d. Exposure to natural weathering agents such as rain, wind and temperature contribute a lot to fast decay of timber.

Steps to avoid deterioration of timber –

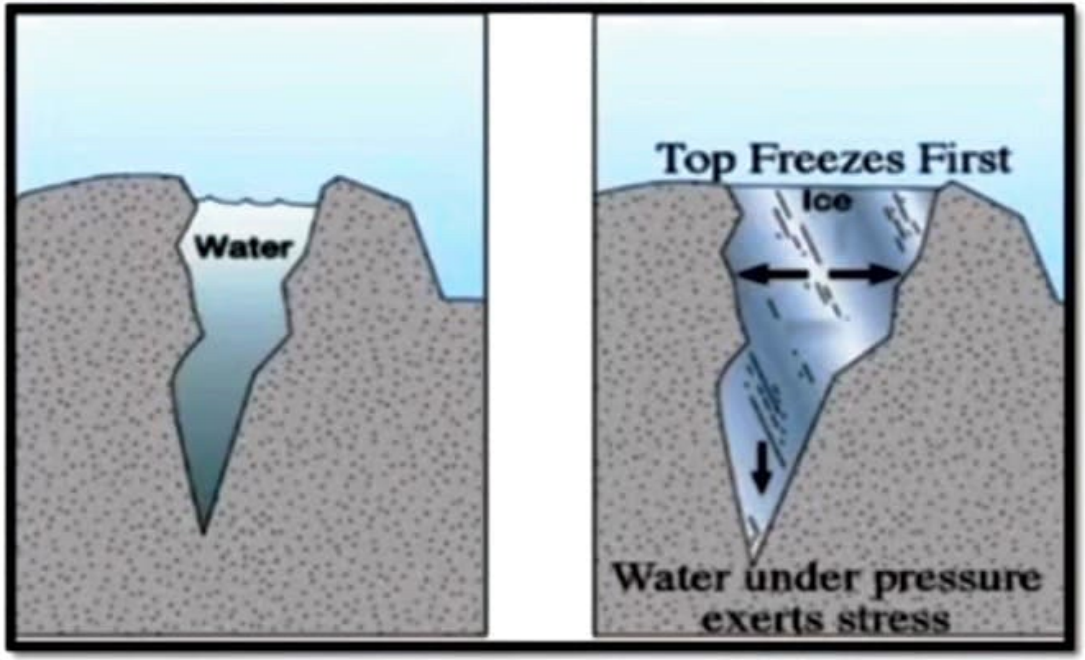
a. Proper seasoning of timber (reduction of moisture content to optimum level) is done to make is last longer.
b. Preservative are used to preserve the timber from decaying. Such treatment is done to ensure a longer, trouble free life of timber.

3. Concrete –

- Concrete is a relatively durable material but its durability is affected due to the following factors.

a. Freezing and thawing –

- Water entering in the pores of concrete freezes in cold climate. Due to increase in volume of water on freezing results into disintegration of concrete.
- Concrete located in exposed condition are more susceptible to such attack.



b. Sub-soil salt attack –

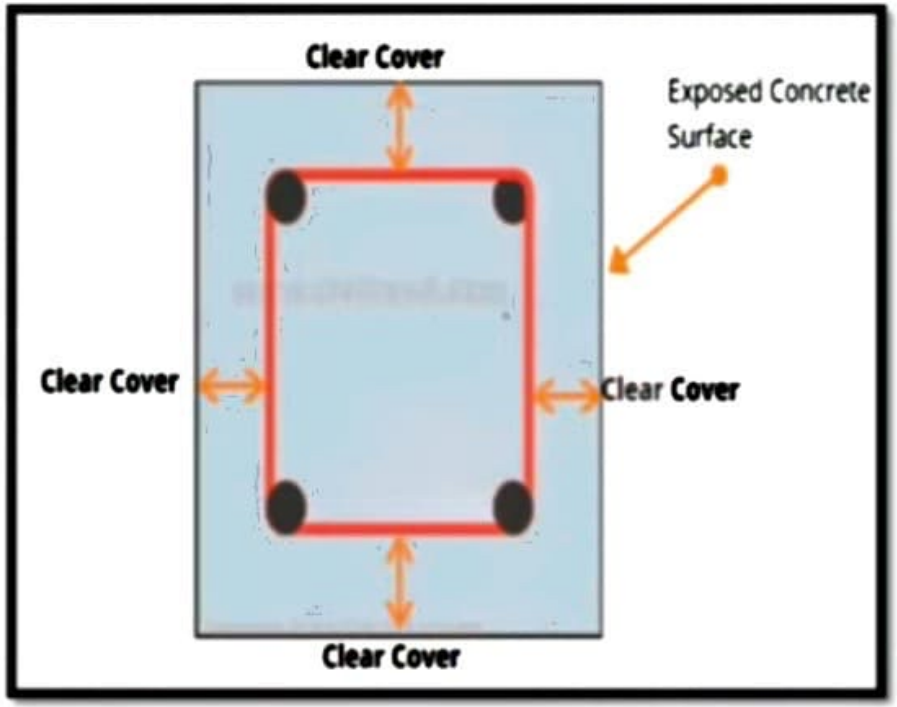
- The water soluble sulphates in soil when comes in contact of concrete cause its expansion, spalling and disintegration.
- The extent of damage of concrete will depends upon the amount and type of sulphate present in the ground water and quality of concrete.

c. Alkali aggregate reaction –

- Silica present in aggregates reacts with the alkalis of cement in the presence of water and cause expansion and subsequent damage to concrete.

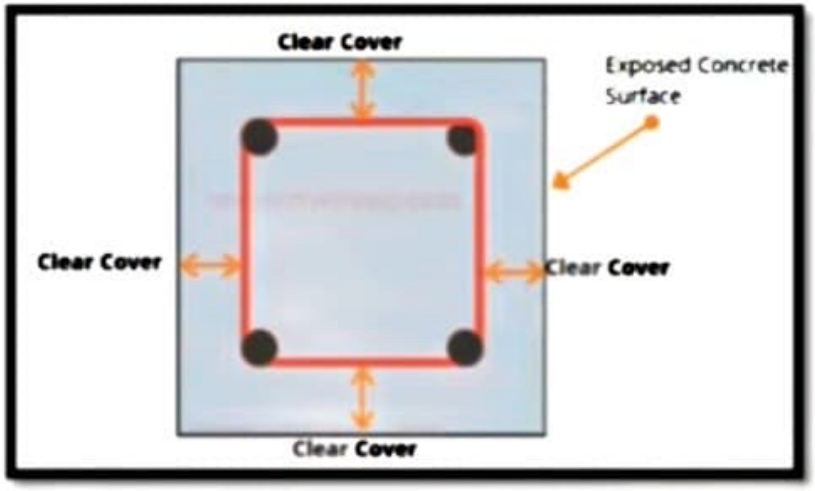
d. Corrosion of steel –

- Corrosion of steel bars in R.C.C. structure reduced the durability of concrete in contact with steel bars.
- Rusting of steel bars causes spalling and cracking of concrete. Deterioration is aggravated in case of concrete is permeable or concrete cover to steel reinforcement is inadequate.



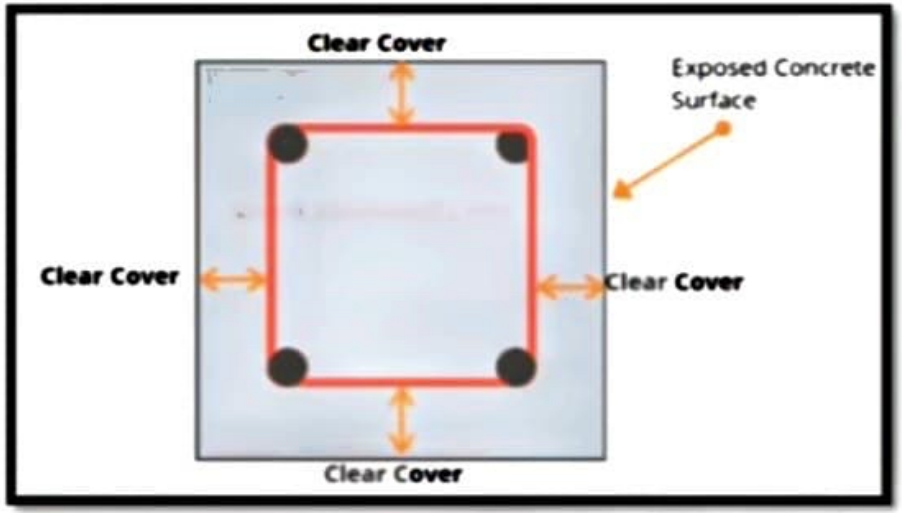
Deterioration of concrete can be controlled by the following steps –

1. Using optimum water cement ratio
2. Using sound and fresh cement
3. Using durable densely graded and non reactive aggregates
4. Using proper batching and mixing equipment and methods
5. Providing thorough and uniform compaction
6. Providing proper curing
7. Providing proper cover to R.C.C.



4. Metals –

- Metals used in building have good durability. Durability of metal is affected by corrosion. It is aggravated by the presence of dissolved atmospheric gaseous pollutants, dirt etc. The risk of corrosion is increased when metals are in contact with other building material such as brick or plaster.
- In R.C.C. member it is the concrete cover that cracks first. Therefore the cover to steel in R.C.C. structure should be according to the exposure of the structure to the environment. When steel corrodes very much, then only we can see both broken concrete and corroded steel.



- The cast iron pipes buried in the ground also get rusted but do not deteriorate. The rusted part remains in its place and acts as a protection against further corrosion. Many cast iron pipes under ground last for very long period in the field.

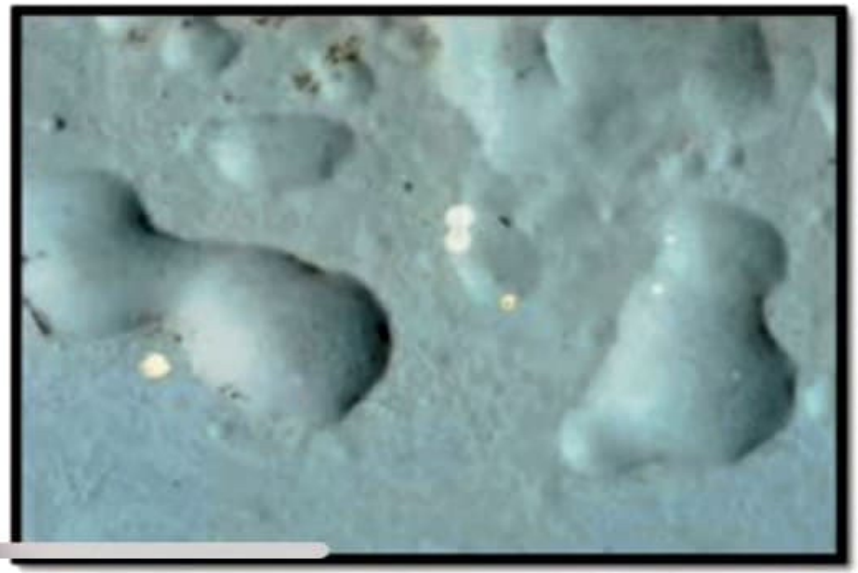
5. Paints –

- Paints are coating of coloured liquid material applied on the surface of the finished parts of the building, which on drying forms as an impervious coat and protects the surfaces form the effects of atmospheric agencies, decay of wood and corrosion of metal and also serves as a decorative surface.

Defects observed in Paints –

1. Blistering –

- This is due to trapping of water vapor behind the painted surface. This forces the paint into little bubbles or blisters.



2. Fading –

- When the painted surface is exposed to direct sunlight, gradual fading of colour due to loss of brightness of pigment occurs.

3. Blooming –

- This is the development of dull patches due to presence of moisture or chilling of surface glossy coat.

Other defects in paints are due to following reasons –

a. Use of poor material –

- All the paints should be selected of good quality in relation to their exposure condition.

b. Application on damp surface –

- Dampness breaks down the adhesion of the paint with the surface of the component causing flaking and cracking form the surface.

c. Poor workmanship –

- It is one of the main cause of paint deterioration and defects.
- Poor workmanship can be attributed to incorrect, inadequate or non existent surface preparation. Over thinning of paint, improper brush selection, poor brushing techniques and failure to apply the specified number of coats may results in deterioration of paints.

6. Plastics –

- A wide range of plastic are used in building. Polyvinyl chloride (PVC) has the widest application. special plastic are used for large drainage chamber, plumbing, drainage fittings and wall tiles.

The following defects are observed in plastics –

a. Short wave solar radiation degrades plastic by causing embrittlement and change in surface appearance.
b. Moisture in general has little effect but can reduce bond strength between glass fiber and polyester resin.
c. Cracking of polyethylene is cold water cisterns is caused by use of oil based jointing compounds.
d. Plastic creep under continuous loads and special precaution are need when stresses are high.

7. Stones –

- The following deterioration are observed in naturel stones due to various weathering agencies.

1. The atmospheric pollution causes deterioration of limestones and sandstone. If wetting and drying are frequent due to rainfall, the surface of the stone gets slowly eroded.
2. Frost may also attack some limestone.
3. Marble is attacked by sulphuric gases.
4. One major cause of damage in all types of stones can be due to corrosion of embedded fixtures. Rusting of iron and steel cramps and dowels cause extensive damage to limestones and sandstones.

Content

Investigation
Diagnosis
Objective of investigation of defects
Systematic approach/procedure of investigation
Steps involved in the systematic approach of investigation

Introduction –

- All the building components start deteriorating after certain period due to action of various natural forces like rain, sunlight, wind etc.
- Sometime there may be problem in the buildings due to use of poor construction material, due to poor workmanship or faulty design etc.
- This deterioration, if left unchecked can cause serious defects in building and these defects can become the source of building failure.
- This adverse situation can be avoided or at least reduced considerably if we are able to understand the reason of these defects.
- Hence investigation of defects is the most important aspect in order to minimize the adverse effects of defects.

Investigation –

- Investigation is the process of examining and inspecting the structure or its components to collect information on the basis of which the exact cause of defects can be known so that effective remedial strategy can be adopted accordingly.

Diagnosis –

- Diagnosis is the interpretation of the results obtained from investigation. The general approach to diagnosis the defects in a structure is to critically analyze all the probable cause of defects and ultimately identify the true cause.

Objective of investigation of defects –

1. To identify the causes of defects.
2. To identify the sources of defects.
3. To classify the damages as structural or non structural
4. To assess the extent of damage due to corrosion, fire, earthquake or any other reason.
5. To assess the residual strength of the structure or its components.
6. To assess the rehabilibility.
7. To prioritise the defective elements as per urgency for repair.
8. To select and plan the effective remedy.

Systematic approach/procedure of investigation –

- Investigation of defects in building/structure are required to collect the information on the basis of which diagnosis is done.
- if is necessary that investigation of defects is carried out in a systematic and scientific manner.

A systematic investigation should fulfill the following requirements –

1. It should be well planned
2. It should be thorough and timely
3. It should examine all possible aspects of defects.
4. The scope and objective of investigation should be clearly decided.
5. The investigation should have sound and thorough knowledge about all possible aspects.
6. Investigation should be carried out using appropriate tools and kits.

The following steps are involved in the systematic approach of investigation –

1. Preliminary investigation about the defects in structure
2. Physical inspection of the structure
3. Testing of all the material involved in the structure
4. Non destructive tests
5. Detailed diagnosis of defects
6. Study of all the available relevant documents
7. Estimation of actual loading
8. Checking the design and to see if there is any error
9. Consideration of environmental effects
10. Appropriate strengthening of members as per requirements
11. Relevant repair as per requirements

Content

Scope of investigation
Factors to be ascertained (to find out) during investigation of defects
Preliminary investigation
Sources of information
Systematic steps of diagnosis of defects are given below

Scope of investigation –

- The scope of investigation of a defect depends mainly on the amount of fund allocated for this purpose and the effort that can be spent on it.

The scope of investigation involves the following –

a. Nature of the defects
b. The accuracy with which cause of defects needs to be identified
c. The primary aim of investigation of the defects

Factors to be ascertained (to find out) during investigation of defects –

- The following factors must be ascertained during investigation of defects in structure

1. Appearance and type of cracks
2. Load carrying capacity of the affected structure
3. Difference in design load and actual service load, if any.
4. Spread of defects (localized or over the entire area)
5. Permeability of the affected concrete
6. Extent and source of dampness in building
7. Chloride level of concrete
8. Carbonation and depth of carbonation of affected concrete
9. Degree of corrosion
10. Type of defects in woodwork
11. Causes of leakage in water supply and drainage system

Preliminary investigation –

- Deterioration of a building structure means certain elements of the building has become incapable of serving the expected use due to some damages in the element.
- The main consideration of such investigation is to find the source and root cause of the damaging force.
- For this purpose, it is very important to collect all the relevant data related to the affected structure

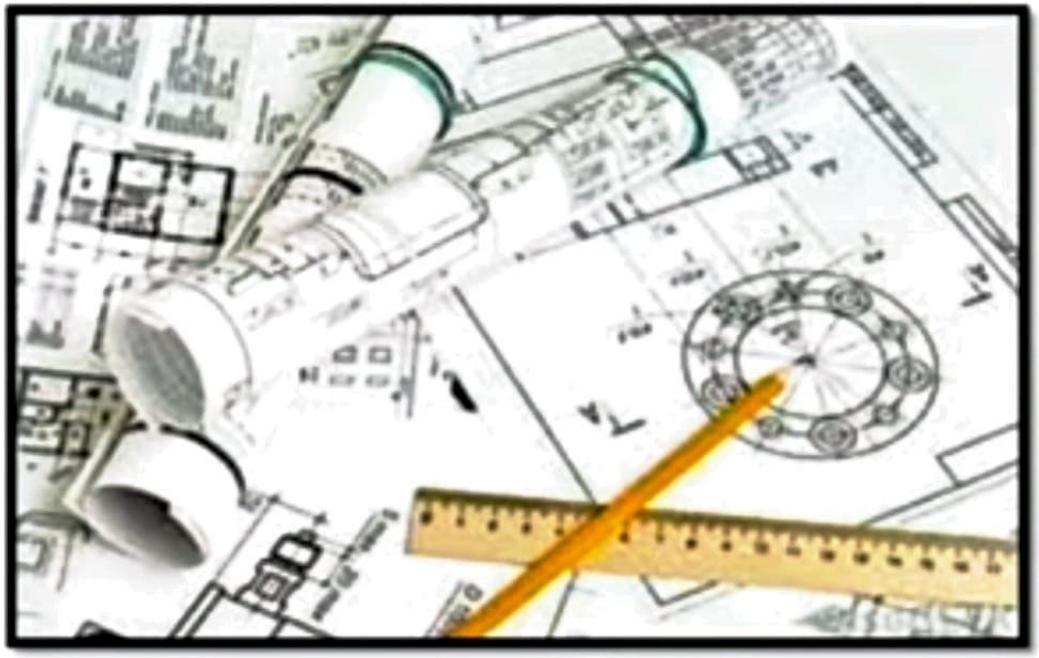
The following steps are taken in the preliminary investigation of the defects in building –

1. The deteriorated building is kept undisturbed
2. During the first visit to the site, photographic data of the deteriorated building is collected
3. All symptoms at the site are carefully recorded for further analysis
4. All the concerned persons are interviewed to elicit information about the probable cause of defects.

Sources of information –

1. Drawing and specification –

- These provide the details of materials used and method of construction. But in actual practice there may be some deviation during the construction form the drawings and specifications.
- Hence actual details of construction can be known by actual inspection, other site notes etc.



2. **Consultant/Architect's instruction –**

- It will be helpful in providing clue to variation in material and specification changed during the course of construction.

3. **Site notes, reports –**

- These provide information regarding the sort of difficulties encountered, the quality of workmanship achieved, the extent to which precautions were taken to protect material at site and weather condition experienced during construction.

4. Maintenance manuals and other records –

- These provide accurate details of alternation and addition carried out since the completion of building and history of any defect.

5. Interviews –

- Interviews with the users and those associated with design construction and maintenance can provide useful information on various aspects of building defects.

6. **Inspection –**

- All the important information regarding deterioration of building can be obtained through inspection of the deterioration building.
- Information regarding quality of original construction work, ageing, crack patterns, deflections, relative displacements etc. are obtained during inspection.

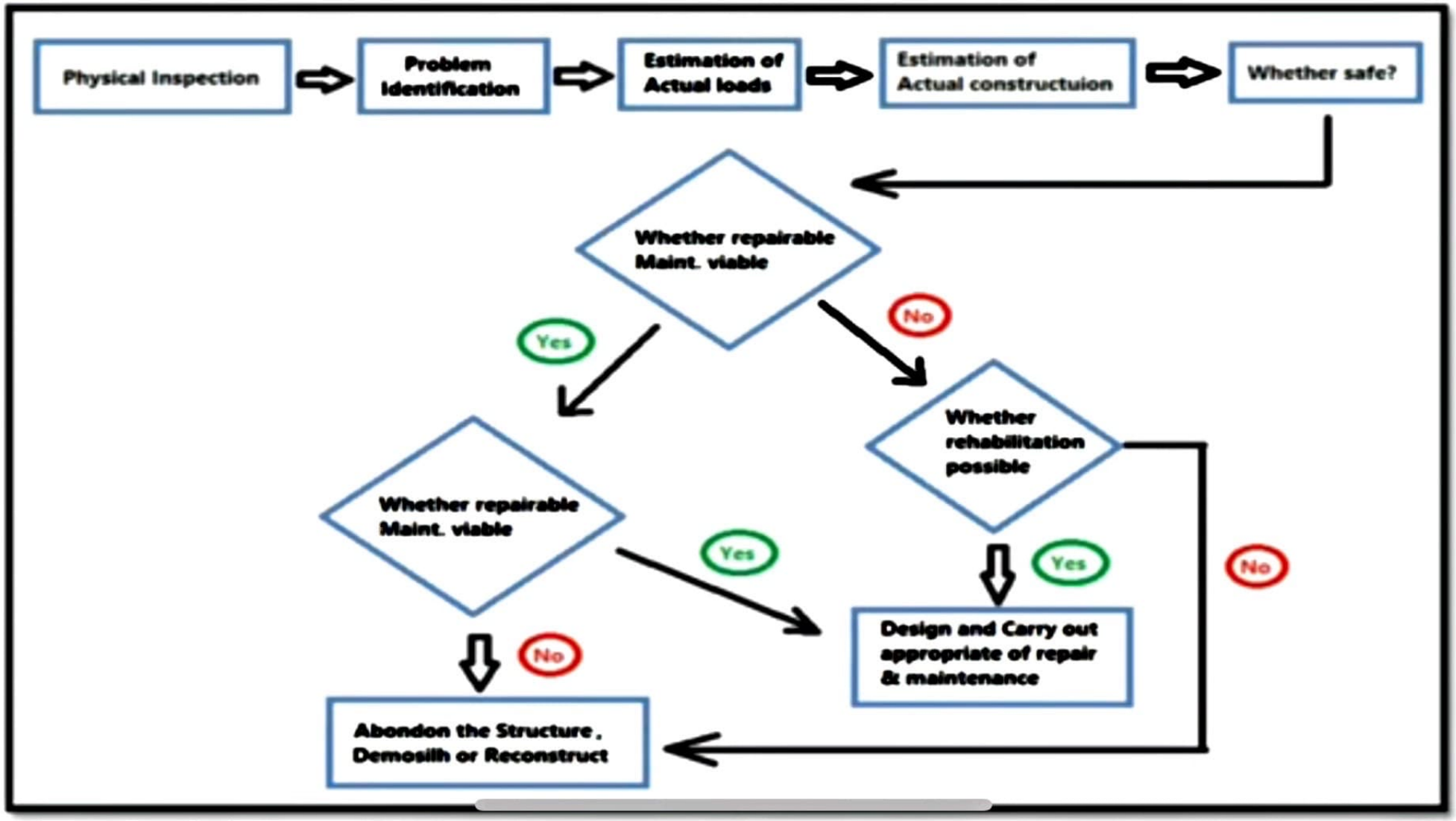
7. **Tests and measurements –**

- Various tests and measurements provide information on properties of material such as moisture contents, physical and chemical properties, cracks and deflections etc.

Detailed steps for diagnosis of defects –

- Diagnosis of defects is a very challenging task which plays key role in the assessment of damage to structure.
- Assessment of damage is necessarily an interactive procedure based on the data obtained, form investigation.
- To minimize the likelihood of errors, damage assessment must be carried out carefully in a scientific manner.
- Diagnosis of defects can be done on the basis of documents, interviews with the stakeholders etc.
- Sometime symptoms of damage in buildings are common but the causes responsible for such damage may be deferent.
- Hence diagnosis the exact cause of damage, out of a large number of possible causes, is actually a challenging and demanding task.

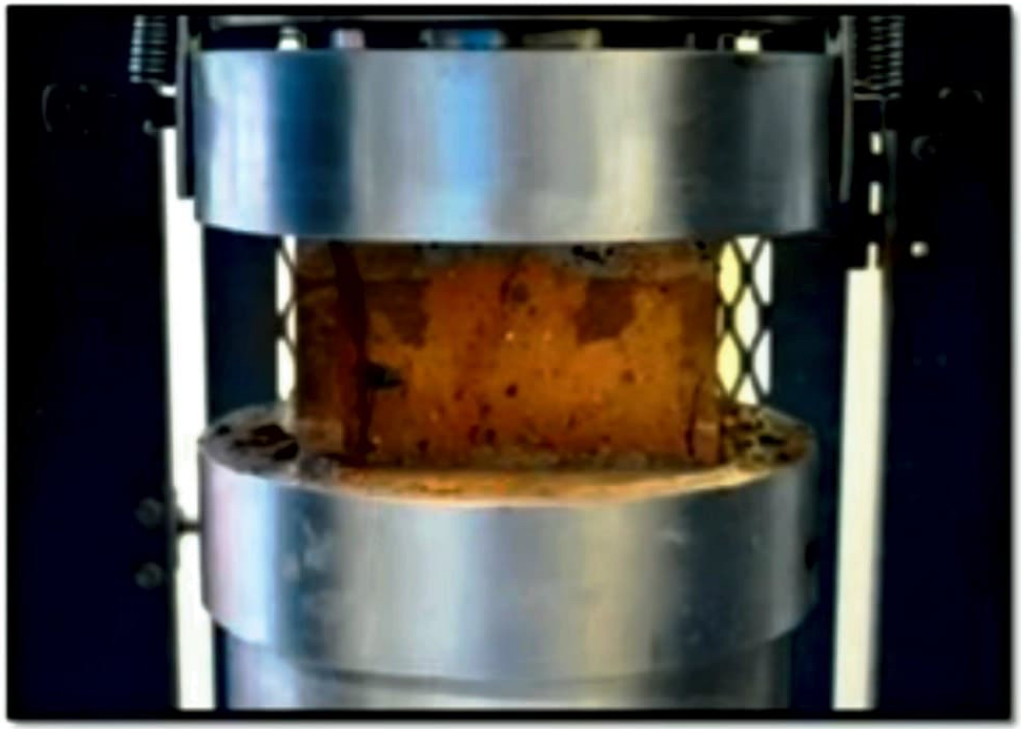
Systematic steps of diagnosis of defects are given below –



Content

Non destructive tests (NDT)
Purpose of Non destructive tests (NDT)
Rebound hammer test
Ultrasonic pulse velocity (UPV) Test
Concrete core tests

Non destructive tests (NDT) and destructive tests –



Non destructive tests (NDT) –

- Non destructive tests are used to assess the in-situ properties of structure. The following are the salient features of non destructive tests.

1. These tests are less time consuming and relatively inexpensive
2. This tests are used for diagnosing the defects without disturbing the performance of the structure members
3. These tests can be used to assess the in situ strength, equality, location and the extent of cracks, voids and honeycombs.
4. These tests are useful in determination of extent of corrosion in the structure.
5. These tests can be helpful in confirmation of suspected deterioration of the structure.
6. These tests are more useful in case where data of structure (like drawings, grade of concrete used) is not available.

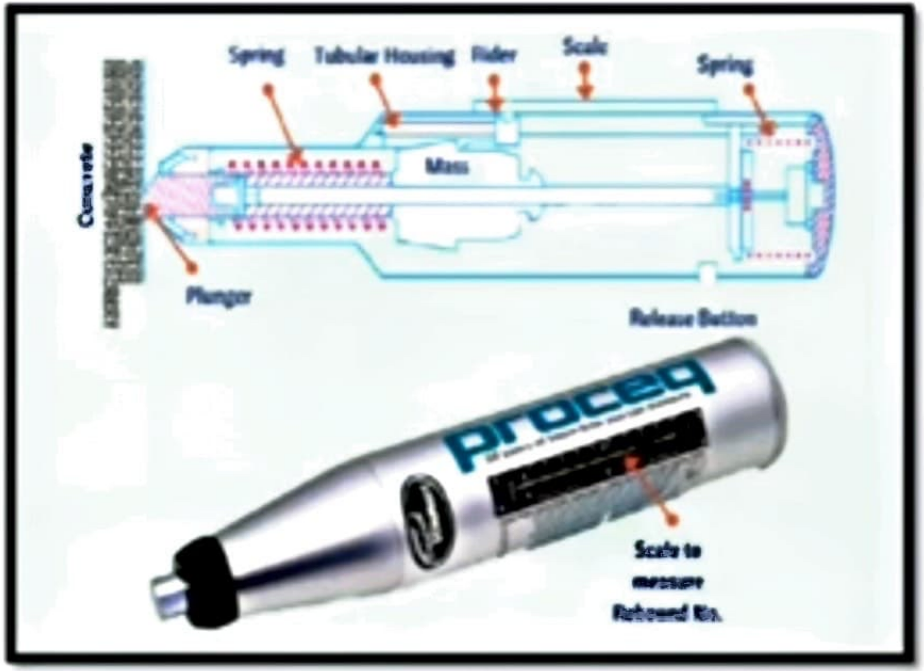
Purpose of Non destructive tests (NDT) –

1. Determination of concrete strength, presence of cracks, voids and honeycombing.
2. Determination of depth of concrete cover, bar diameter and spacing
3. Determination of extent of corrosion of reinforcement
4. Determination of chemical attack on concrete
5. Determination of permeability
6. Determination of defects in metals and welded joints

Some commonly used important Non Destructive Tests –

1. Rebound hammer test –

- This test is conducted to get an idea about the equality of concrete.
- The typical rebound hammer is shown in figure below.

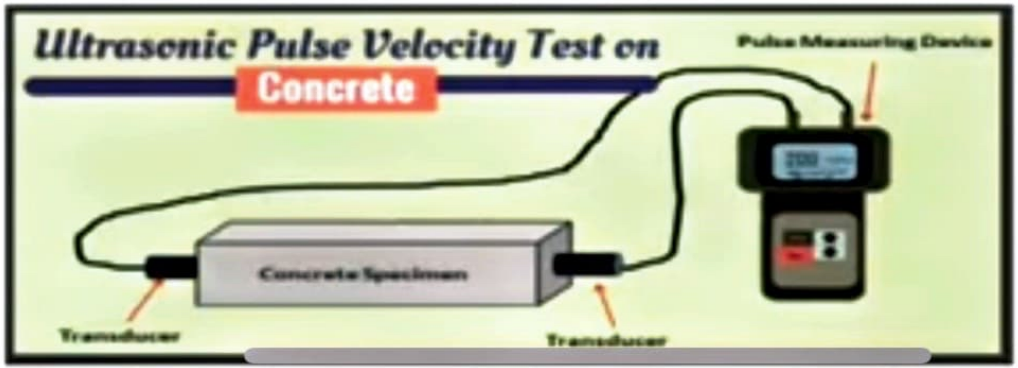


- The hammer is applied on the surface of the concrete member (Beam, column etc.) to be tested at a particular point.
- The elastic rebound of the hammer after impact is measured on a scale as a Rebound number, which is a measure of surface hardness.
- The hammer can be pressed horizontally or vertically, upward or downward.
- This test is done on many points on a grid to get an average value.
- The estimation of concrete compressive strength of the cover and the below concrete is obtained form the test results.

Average Rebound Number on the tester	Quality of concrete
> 40	Very good (hard layer)
30 to 40	Good
20 to 30	Fair
< 20	Poor

2. Ultrasonic pulse velocity (UPV) Test –

- This is a recognized non destructive test to qualitatively assess the homogeneity of concrete.
- This test can also detect internal flaws, voids or cracks and segregation in concrete of the structure.
- This test consists of measuring travel time (T) of ultrasonic pulse produced by a transducer, held in contact with one surface of the concrete member under test and receiving the same by a similar transducer in contact with the surface at the other end.
- With the path length (L = distance between the two probes) and the time of travel (T), the pulse velocity (V = L/T) is calculated.



- Higher the elastic modulus and density of the concrete higher is the pulse velocity.
- This test can be conducted on three modes, as shown below. They are called direct, semi – direct and indirect. Of these the direct test is the best. The other tests are carried out where the direct test cannot be conducted due to obstructions.
- The pulse velocity obtained in direct test is related to the condition of concrete as given in table below.

Pulse velocity obtained by Direct test (Km/sec)	Condition of concrete
> 4	Excellent
3.5 – 4.0	Good
3.0 – 3.5	Medium
< 3.0	Poor

- This test is done in many places in the building. Usually, the results of this test may vary from member to member.
- But a number of readings should be used to assess the general quality of construction.
- This test is also done on a grid marked on the concrete member.

The pulse velocity in concrete may be influenced by –

1. Path length
2. Presence of reinforcing bar
3. Moisture content of the concrete the velocity is increased with increased moisture content.

Detection of defects –

- In the region of imperfections, the ultrasonic pulse is diffracted around the periphery of the defect and takes more time to reach the receiving transducer.
- Thus the transit time is more and the ultrasonic pulse velocity is reduced.
- The magnitude of reduction in the pulse velocity indicates the extent of imperfection.

3. Concrete core tests –

- This is the direct way of measuring actual strength of concrete.
- Concrete cores are cut by means of a rotary cutting tool with diamond bits. In this manner, a cylindrical specimen is obtained.
- The core is then soked in water, capped with molten sulphur to make its ends plane and parallel.
- This core is then tested in compression. In this way, we get the compressive strength of concrete used in the structure which gives the idea about the quality of concrete.