UNIT-III

FAILURES OF BUILDINGS

Definition of building failure :- it occurs when the building loses its ability to perform its intended (design) function.

Types of failures :-

1) structural failures (or) physical failures
2) performance failures.
3) ~~notable failures~~

① failure of a structure can occur from many types of problems. Most of these problems are unique to the type of structure as to the various industries. however, most can be traced to one of five main causes.

structural failure is an aspect of engineering which deals with the ability of a structure to support a designed load (weight, force, etc...) without breaking, tearing apart, or collapsing, and includes the study of breakage that has previously occured in order to prevent failures in future designs.

structural failure refers to the loss of structural integrity, which is the loss of the load-carrying capacity of a component or member within a structure, or of the structure itself. structural failure is initiated when the material is stressed beyond its strength limit, thus causing fracture or excessive deformations. To construct an item with structural integrity, an engineer must first consider the mechanical properties of a material such as toughness, strength, weight, hardness, and elasticity and then determine a suitable size, thickness, or shape that will withstand the desired load for a long life. structural integrity must always be considered in engineering when designing buildings, support structures, mechanical components. it also see the yield strength, shear, tensile strength consider.

2). performance failure := which means a reduction in function below an established acceptable limit.

another way we classified

1) minor failures
2) major failures

due to improper selection of materials, incorrect-sizing, improper heat treating failing to adhere to the design, or shoddy workmanship. these types of failure can occoon at any time, and are usually unpredictable.

the fourth is also unpredictable, from the use of defective materials. the material may have been improperly manufactured, or may have been damaged from prior use.

the fifth cause of failure is lack of consideration of unexpected problems. vandalism, sabotage, and natural disasters can all overstress a structure to the point of failure.

poor construction practices :-

incorrect placement of steel :- incorrect placement of steel can result in insufficient cover, leading to corrosion of the reinforcement. if the bars are placed grossly out of position & in the wrong position, collapse can occoon when the element is fully loaded.

b) Inadequate cover to reinforcement :- inadequate.

Cover to reinforcement permits ingress of moisture, gases and other substances and leads to corrosion of the reinforcement and cracking and spalling of the concrete

c) incorrectly made construction joints :- the main faults in construction joints are lack of preparation and poor compaction. the old concrete should be washed and a layer of rich concrete laid before pouring is continued. Poor joints allow ingress of moisture and staining of the concrete face.

d) Grout leakage :- Grout leakage occurs where formwork joints do not fit together properly. the result is a porous area of concrete that has little or no cement and fine aggregate.

e) poor compaction :- If concrete is not properly compacted by ramming or viboration the result is a portion of porous honeycomb concrete. This part must be hacked out and recast. complete compaction is essential to give a dense, impermeable concrete.

minor :- The failure may occur due to the poor quality of materials like

cement - high alkali cement

sand

coarse aggregate - reacting Agg - AAR

reinforcement, corrosion, carbonation, chloride attack

due to this type of failures the durability of the structure get reduced.

- cement - if we use $\frac{w}{c}$ ratio more strength ↓, se
- improper mix proportions.
- types of aggregates :- rounded aggregates use strength decreas, Angular Agg. use strength increases
- due to creep, segregation, freezing & thawing, carbonation, Abrasion, erosion, pitting, Alkali Aggregate reaction.

major :-

1) over loading
2) poor quality of materials
3) Design - limit state method
4) poor construction practices
5) failures of column due to corrosion of Reinforcement

6) due to improper transfer of loading

7) poor concrete mix and water quality

8) Beach sand in construction

9) failure of soil

causes of failures :-

The first, whether due to size, shape, or the choice of material, is that the structure is not strong and tough enough to support the load. if the structure or component is not strong enough catastrophic failure can occur when the overstressed construction reaches a critical stress level.

The second is instability, whether due to geometry, design or material choice, causing the structural to fail from fatigue and corrosion. causing cracks to slowly form and then progress through cyclic loading. failure generally occurs when the cracks reach a critical length, causing breakage to happen suddenly under normal loading condition.

The third type of failure is caused by manufacturing errors. This may be

(f) Segregation :-

1) dropping the mix through too great a height in placing (chutes or pipes should be used in such cases)

2) using a harsh mix with high coarse aggregate content

3) large aggregate sinking due to over-vibration or use of too much plasticizers.

(g) Poor curing :- a poor curing procedure can result in loss of water through evaporation. loss of water can cause shrinkage cracking. during curing the concrete should be kept damp and covered.

h) Too high a water content :- excess water increases workability but decreases the strength and increases the porosity and permeability of the hardened concrete.

Fire damages :-

cooking equipment was the leading cause of residential home fires. Based on information gathered by the National Fire Prevention Association (NFPA) cooking equipment is again the leading cause of fires.. cooking equipment is responsible for one in four office fires, and thankfully these fires occur more during building occupation. resulting in only 6% of building damage when compared to other

others causes. The second leading cause of fires in office buildings is probably what you'd guess - electorical distribution and lighting equipment (12.1.) heating equipment is number three (11.) followed by intentional fires at 10.1. - smoking still causes more fires than office equipment.

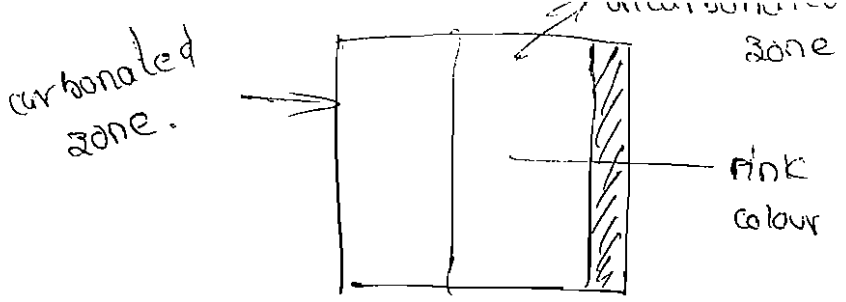
diagnostic testing methods and equipments :-

1) carbonation test
2) covermeter
3) half cell potential measurement
4) Infrared thermography
5) Resistivity measurement
6) surface hardness
7) surface penetration radar server
8) ultra sonic pulse velocity measurement

① C.T :- ① - phenapthalein solution is used to measure

② the concrete cube is taken and phenapthalein solution is sprayed.

③ phenapthalein turns pink colour in high alkanity conditions and indicates uncarbonated zone.



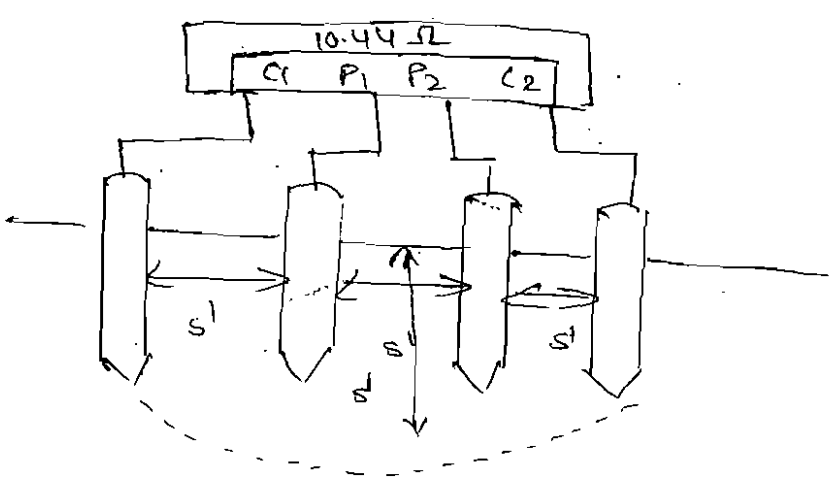
② covermeter :- this method is mainly used for to eating reinforcing steel within a concrete member by measurment of the change of an electro-magnetic feild caused by steel embedded in the concrete.

③ Half cell potential measurement :- the risk of corrosion of the reinforcement in the immediate region of the test location may be related empirically to the measured potential difference by the half cell equipment. the test involves measurment of the potential difference blw the metal in reference electrode and the steel in concrete.

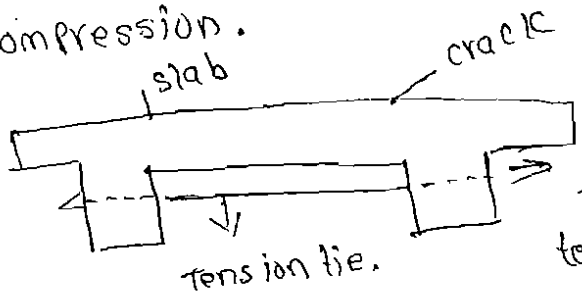
④ Infrared thermography :- IR involves the recording the surface temp differentialls on a concrete member undergoing heating or cooling. hidden feature, including voids of cracks, will influence the local rate of heating of cooling and may be detecte

⑥ surface hardness :— ~~there are different types of~~ this test methods involves applying a rebound hammer to the concrete surface. the hammer measure the rebound of a spring loaded mass impacting against the concrete surface. it rebound is dependent on the hardness to the concrete and is measured by the test equipment By reference to the convertion chart, the rebound value can be used to determine the compressive strength of concrete surface.

⑤ Resistivity measurment :— measurment of electrical resistivity to asses the corrosion risk of reinforced concrete structers.



External stress :- The development of cracking in concrete is due to tensile stress and can be arrested by suppressing this stress. Furtheron the cracks can be closed by inducing a compression force sufficient to overcome the tension and to provide a residual compression.

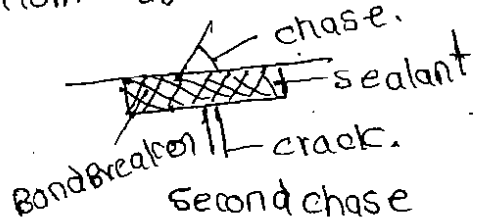


Tie rod tensioned by tightening the nuts against the anchorage system.

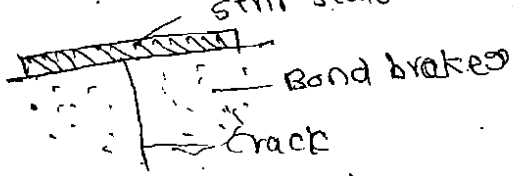
Blanketing :-

Type-I :- in such a joint an elastic sealant is used the sealant material is done which returns to its original shape when the externally induced stress is removed

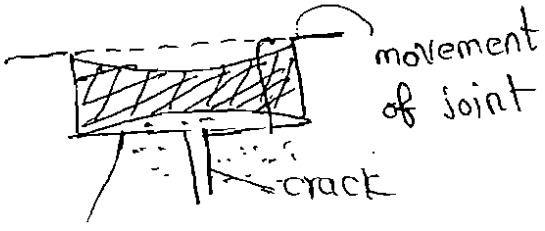
Type-II :- it is a mastic-filled joint and is similar to the application of an elastic sealant expect that the bond breaker is omitted. The sealant is bonded to the bottom as well as to the sides of chased dispersion.

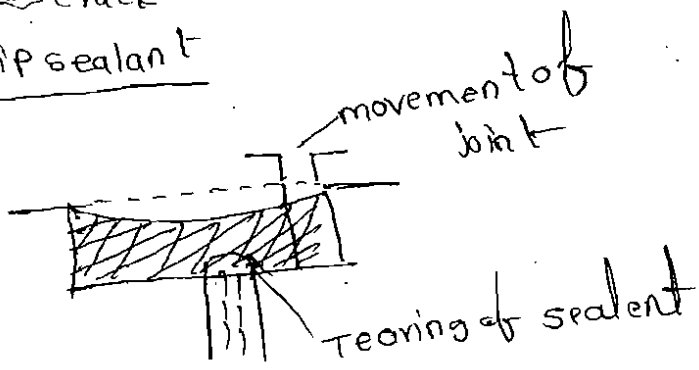


Second chase

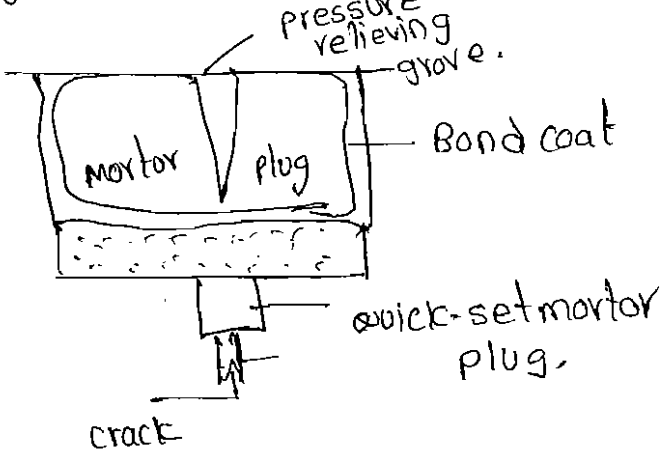


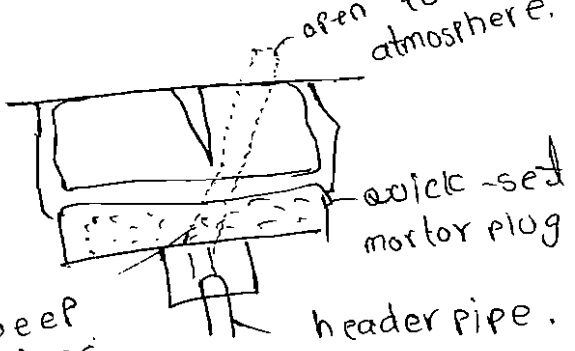
strip sealant



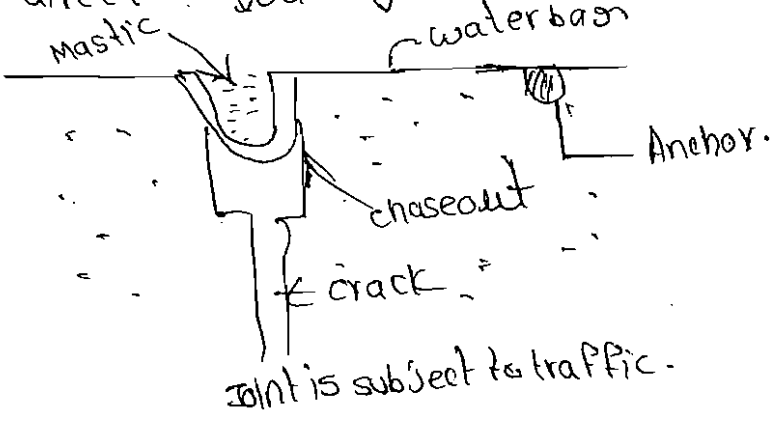


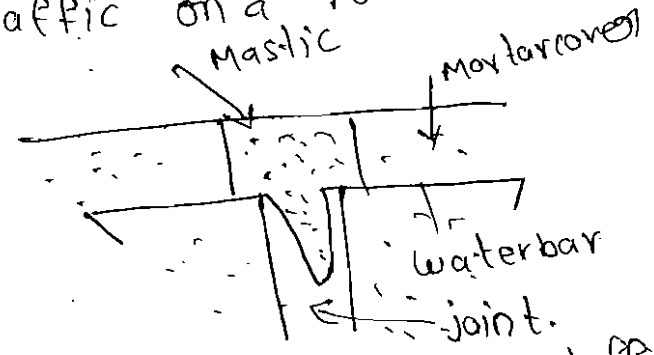
Type-III :- it is a mortar-plugged joint. A recess in the form of a trapezoid to accomodate the mortar plug is made. this recess is filled with mortar.





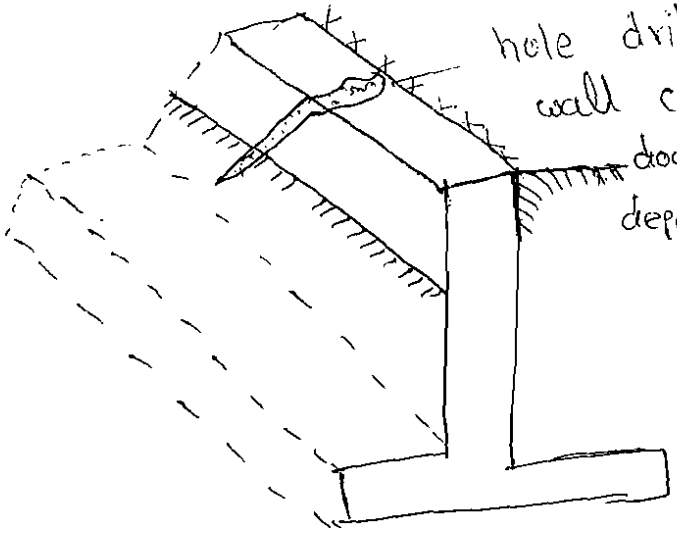
Type IV :- a crimped water bar generally installed at locations where the bar is not subject to direct loading such as traffic on a pavement.





Overlays :- overlays are used to seal cracks, they are useful and desirable when a large number of cracks are present and treatment of each individual crack would be too expensive and laborious.

Grouting :- Grouting is performed in a similar manner as injection of an epoxy. however, the use of an epoxy is a better solution except where considerations of fire resistance or cold weather prevent such use. In these cases, grouting is an effective alternative.



Sealing a crack by drilling and plugging.

Autogenous healing :- The inherent ability of concrete to heal cracks within itself is termed autogenous healing. This is used for sealing dormant cracks such as in the repair of precast units cracked during handling. rectifying cracks developed during the driving of precast piling, sealing of cracks in water tanks, and sealing of cracks which are the result of temporary loading condition. This property also provides some increase in the strength of concrete damaged by vibration during setting and concrete disrupted due to freezing and thawing.

Methodology for investigation of failures :-

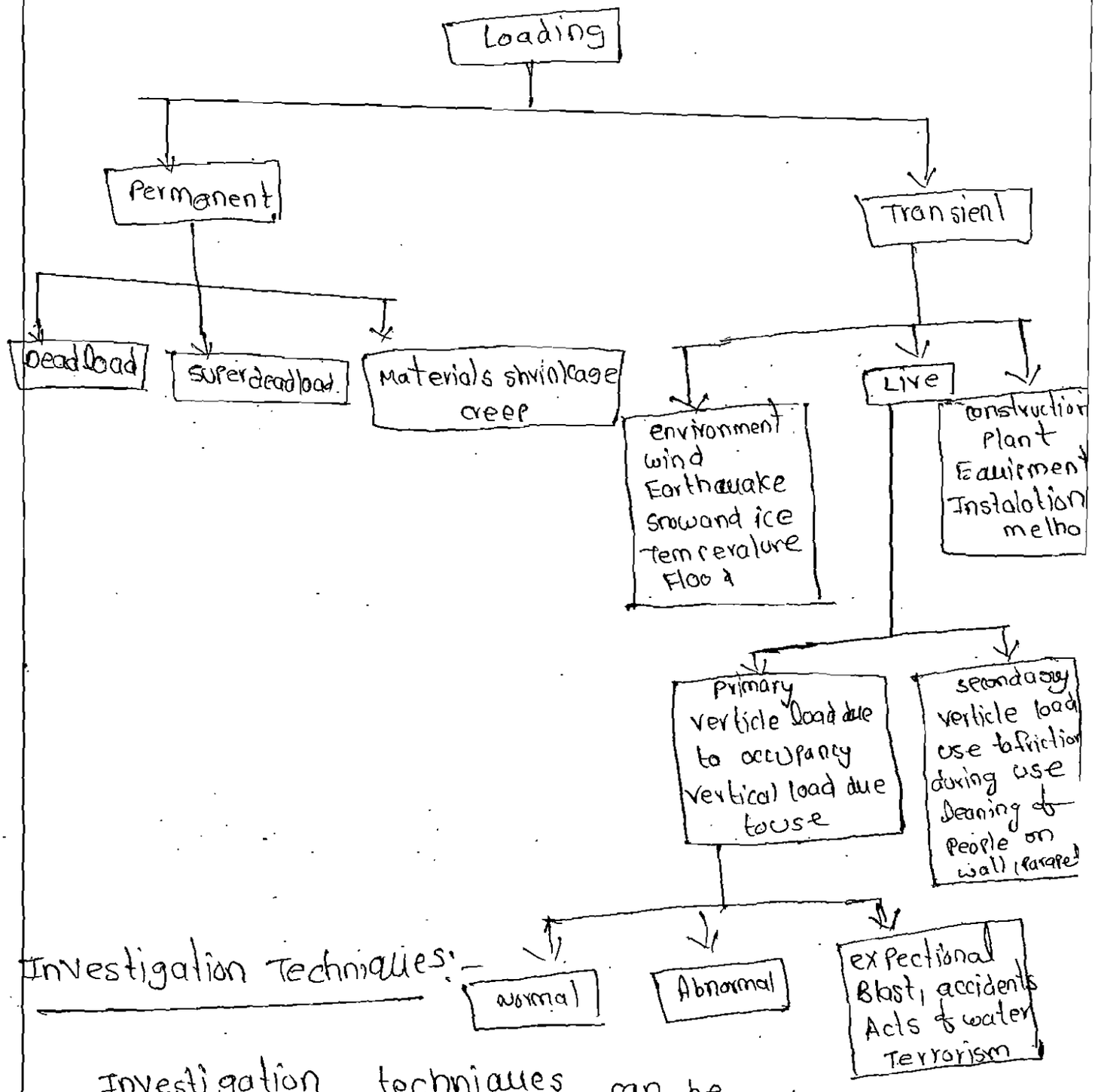
Investigation plan :- there are several important factors which need consideration while investigating an existing building. the investigation evaluates the structure from stability and functionality points of view.

Preliminary investigation :-

- a set of built plans
- construction specifications
- inspection reports
- report on previous investigation
- previous retrofit or repair works
- complaints by occupants
- others problems noticed.

Main investigation :- the purpose of the main investigation is to analyse the structure thoroughly to provide sufficient documentation to form the basis for the design of the remedial work. only rarely would this sort of investigation conclude that the remedial work is not required. however, this could occur if the data from preliminary information was not sufficienty conclusive to make the decision at that stage itself. the main investigation does not require that the condition of the whole building be documented. such investigation

will be costly and time consuming. so only the elements that have been recommended in the preliminary investigation are taken up for a detailed investigation.



Investigation Techniques:-

Investigation techniques can be broadly classified as destructive and non-destructive. But to decide on the technique to be used. visual investigatio and a walk-around survey are to be undertaken firs

Visual Examination :-

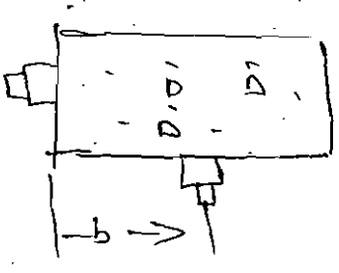
- Detail of the owner and the occupier
- Type of structure
- Dimensions
- Interconnection of elements
- Material Information
- orientation with respect to north
- orientation and alignment with respect to polluting agencies such as traffic, Industry.
- climatic conditions prevailing and wind direction.
- ~~chec~~ signs of deterioration
- Age of building
- Details of maintenance and previous repair and retrofitting.

the equipment and accessories that will help in visual examination are the

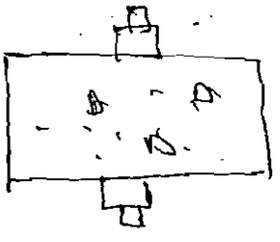
- Building drawing
- Layout plan
- camera
- Binoculars
- A Magnifying glass
- Post it pad for tagging photographs
- A flash light
- A clip board
- A compass
- A tap recorder.

Penetration radar survey :- surface Penetration radar system is used to examine the reflections of short duration pulses from interfaces blw materials with different dielectric constants lying below the surface. Reinforcing bars, voids and ducts may be identified & thickness of slabs may also be determined.

2) Ultra sonic pulse velocity measurement :- The method is based on the study of sound wave propagation through concrete materials & more particularly the measurement of their velocity of transmission ~~of~~ measurement of pulse velocity can be used to determine the integrity of concrete specimen such as homogeneity, Presence of voids, cracks or other imperfection



semi - direct transmission



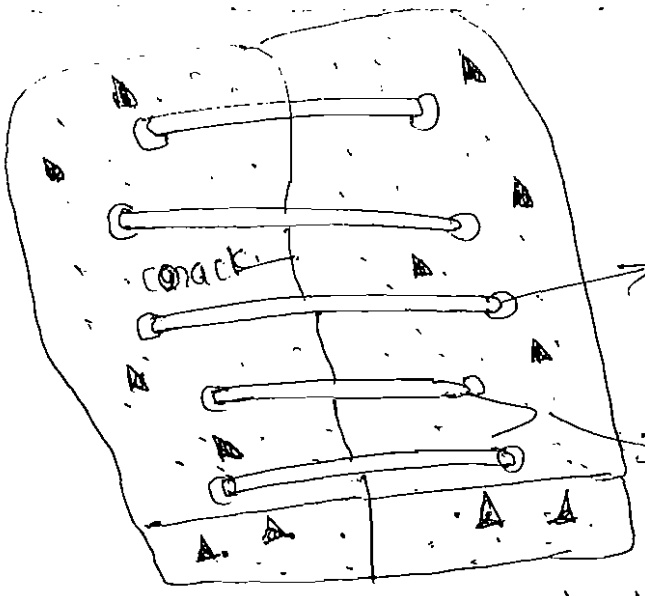
direct transmission

surface transmission

Repair of cracks in concrete :-

Sealing with epoxies :- cracks in concrete may be sealed by injecting epoxy bonding compounds under pressure into the cracks. The usual practise is to drill into cracks from the face of concrete at several location. water or some solvent is injected to flush out the dirt etc. The surface is then allowed to dry. The epoxy is injected into the drilled holes until it flows out through other holes. The work should proceed from bottom to top.

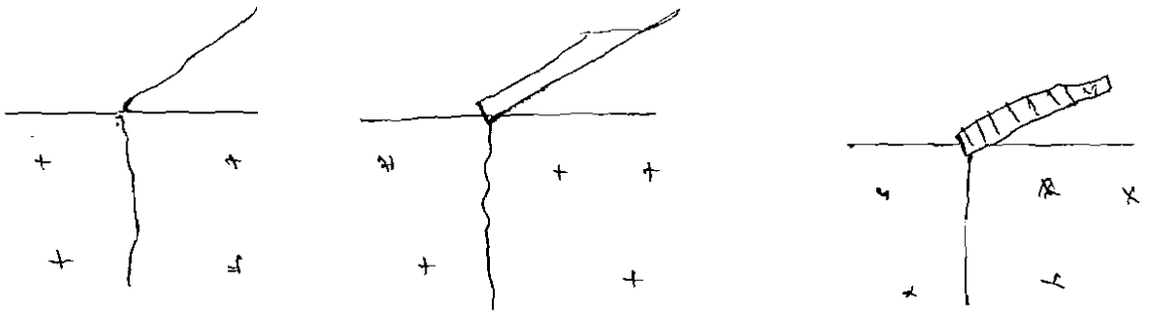
Routing and sealing :- This method involves enlarging the cracks along their exposed surfaces, filling, and finally sealing them with a suitable material. This is the simplest and most common technique for sealing cracks and is used for sealing both fine pattern cracks and larger isolated defects. The cracks should be dormant unless they are opened up enough to put in a substantial patch, in which case the repair may be more properly termed blanketing.



2) stitching the crack will tend to cause it migration elsewhere in the structure. For this reason, strengthening of the adjacent areas of the crack is necessary to take care of additional stress. Moreover, the stitching dogs should be of variable lengths, orientations, and so located that the tension transmitted across the crack does not devolve on a single plane of the section but is spread out well over an area. strengthening of the adjacent sections of concrete may consist in providing external reinforcement embedded in a suitable overlay material.

3) in places where water ingress is likely, the crack should be sealed as well as stitched so that the stitches do not get corroded. A suitable overlay should be applied to achieve this.

4) stress concentrations occur at the ends of cracks hence the spacing of the stiching dogs should be reduced at such locations. The stress concentrations at each end of the crack can be relieved by drilling suitable holes & making the ends rounded.



original crack (a)

Routing (b)

on road pavements it is common to see cracks that have been sealed by pouring hot tar over them this is a simple, inexpensive, and expedient techniaue. In this techniaue, watertightness of the joint is not required and appearance is not important. Routing and sealing of leaking cracks should be done on the pressure face so that the water-aggressive agents cannot penetrate the interior of the concrete and cause side effects such as swelling, chemical attack or corrosion of the rebars.

stitching :- The tensile strength of a cracked concrete section can be restored by stitching in a manner similar to sewing cloth. The following precautions should be taken while adopting stitching as a treatment measure.

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