Materials for repair and rehabilitation: U-1.

Admixtures:

Admixture is a material other than cement, water and Aggregate. Now a days all structures are made (or) Built (or) Construct with concrete. The ordinary concrete fail to achieve requirements and strength to full fill these. introduced "Admixtures". It can be useful to change the properties of concrete without effecting strength. It can be added during mixing (or) placing time.

It can be classified based on requirements. Types of admixtures introduced by Mr. Rimox J. In India Admixtures used from past 10 to 15 years onwards.

@ Accelerators:

It can be used for early setting of concrete. Generally used for repair works. The commonly used accelerate are $CaCl_2$. Gennally mixed 1 to 2%

* It increase strength
* Primary elements in concrete for setting are C_3S & C_2S. $CaCl_2$ act as medium in ingredients
* Increase shrinkage and creep

* Possibility for corrosion of steel structures

1.56 g $CaCl_2$ = 1 g of Chloride ion.

* Now a days Silicates, fluosilicates, triethanolamine are used.

(b) Retarders :-

+ Delay the setting time of concrete

[Sugar, Carbohydrate derivatives, Soluble Zinc Salts]

Note: 0.05 % of sugar in wt. of cement delay 4hrs of setting time.

0.2 to 1% of sugar virtually prevents setting of concrete.

(c) Plasticizers :-

Plasticizers is used for reduction of water. It can be said as water reducers.

The basic products constituting plasticizers are as follows:

(i) Anionic surfactants such as Lignosulphonates and their modifications and derivatives, salts of sulphonated hydrocarbons.

(ii) Nonionic surfactants, such as polyglycol esters, acid of hydroxylated carboxylic acids and their modifications and derivatives

(iii) other products such as carbohydrates

* The calcium, Sodium and ammonium lignosulphonates are the most used
* Plasticizers are used in amount 0.1 to 0.4% by weight of cement.
* Reduction in the surface tension of water.
* Lubricating film between cement particles

2) Super plasticizers :

Super plasticizers is an admixture, these are different from normal plasticizers.

* They use of permit the reduction of water to the extent upto 30% without reducing workability in contrast to possible reduction upto 15% in case of plasticizers.
* Use of super plasticizers are self levelling, self-compacting and for the production of high strengths and high performance concrete.
* Super plasticizers are high range water reducers.
* The use of super plasticizers which has made it possible to use flyash, slag and silicafume

Purpose of Using Admixtures :

* Admixtures are used to modify the properties of fresh and hardenened Concrete.
* Chemical admixtures are used in Construction industry for building strong, durable and waterproof structures.
* They are used to modify the moulding and setting properties of the concrete mix.
* Some chemicals are applied on the surface of concrete to protect it during or after its setting.
* Some chemicals are applied on the surface of moulds used to form concrete to effect easy mould-releasing.
* Some chemicals are applied to bond or repair broken or chipped concrete.
* Mineral admixtures are added to concrete either as a filler or to improve favourably certain desired properties such as durability.
* Some of them are used for Air entraining, damp proofing and increasing workability, durability
* For flowing concrete increasing workability, inducing flowability.

Mineral Admixtures :

(i) Flyash :

The combustion of coal with use of fuel to form powdered. Very fineness size is 0.01 to 0.2 μ sizes.

* It is used for protect the environment pollution
* flyash is used in cement to lessen the heat when compare to ordinary portland cement.
* Setting time is high.
* Strength required for 28 days or 56 days.

(ii) Silica fume :

* The micro silica is very fine size powder
* Silica oxide is 85% taken atleast.
* Mean particle size between 0.1 and 0.2 μ
* Minimum specific surface area 15000 m^2/kg
* Spherical particle shape.
* In this fine pozzolonic materials, it is flyash, silica fume, Blast furnace is used.

(iii) Rice husk ash :

It is the powder formed by the burning of rice husk.

* It is used to control environmental pollution
* 90% Silica, 5% Carbon and 2% K_2O is used.
* The SiO_2 content is used in concrete of admixtures
* The use of rice husk ash is high strength and high impermeability of concrete.
* Used in dam construction

Surkhi:

Surkhi was the commonest pozzolanic material used in India.

* Surkhi is an artificial pozzolona made by powdering bricks or burnt clay ball.
* Surkhi is used for dam construction
* Surkhi is used then less heat is produced.
* In this super plastisizer are also used.

Metakadin:

The research has been done on natural pozzolons, namely on thermally activated ordinary clay and kaolinitic clay. These unpurified materials have often been called metakaolin

natural.

- Fibres
- Wraps

Fibres :

Fibre is a small piece of reinforcing material. They can be circular or flat. The fibre is often described by a convenient parameter called aspect ratio.

$$\text{Aspect ratio} = \frac{\text{Length of fibre}}{\text{diameter of fibre}}$$

Factors effecting properties of fibres :

1. Volume of fibres :

The increase in the volume of fibres, increase linearly the tensile strength and toughness of composite. Use of higher percentage of fibre is likely to cause the segregation and harshness of concrete and mortar.

2. Aspect ratio of fibre :

It has been reported that upto aspect ratio of 75, increase in aspect ratio increases the ultimate strength of concrete linearly. Beyond 75, relative strength and toughness is reduced.

3. Orientation of fibres :

The fibres aligned parallel to the applied

load offered more tensile strength and toughness than randomly distributed or perpendicular fibres.

4.) Workability and Compaction of Concrete:

Incorporation of steel fibres decrease the workability considerly. Another consequence of poor workability is nonuniform distribution of fibres. Workability and compaction standard of mix is improved through increased w/c ratio by the use of some kind of water reducing admixtures.

5.) Size of Coarse aggregate:

The maximum size of coarse aggregate should be restricted to 10mm to avoid appreciable reduction in strength of composite.

6.) Mixing:

Mixing of fibres needs careful conditions to avoid balling of fibres, segregation. It is important that the fibres are dispersed uniformly throughout the mix, this can be done by the addition of fibres before water is added.

Types of fibres:

* Glass fibres
* Carbon fibres

Glass fibre :

It has very high tensile strength of about 1020 - to 4080 N/mm². Glass fibre which is originally used in conjunction with cement was found to be effected by alkaline condition of cement. So alkali-resistant glass fibre by trade name "CEM-FIL" has been developed and used.

Carbon fibre :

It possesses very high tensile strength 2110 N/mm² to 2815 N/mm² and youngs modulus. The use of caibon fibres for structures like cladding, panels and shells will have promising future.

Wraps :

Wraps are sheet like materials used to regain the design strength of the concrete.

Glass and Carbon fibre wrapping technology :

This fibre wrapping can be used where concrete losses its capacity or design strength due to corrosion change in use and or the design code demands increases in load carrying capacity. It can also be used for restoration of the damages RCC structures

and to regain its design strength

Fibre wrapping is the latest strengthening or enhancement technology for reinforced concrete and masonry structural members. It is used for flexural, shear or confinement strengthening of structural members, and ensure minimum disturbance to the structural members as compared to other conventional methods.

Advantages:

* Multi functional, can be used in bending and in shear.
* Low in weight
* ~~Flexible~~ Available in any length.
* flexible, fits around any given structural element
* Excellent chemical and weathering resistance
* Low overall thickness
* Economic application
* Easy to use solvent free impregnating resin

Another Types of fibres:

① Steel fibre:

It is one of the most commonly used fibre. Generally, round fibres are used. The diameter may

Vary from 0.25 to 0.75 mm. Use of steel fibre makes significant improvements in flexural, impact and fatigue strength of concrete.

Eg: Dramix glued steel fibre - majorly used in the production of tunnel segments for channel tunnel.

② Poly propylene & nylon fibres:

These are found to be suitable to increase the impact strength. They possess very high tensile strength, but their low modulus of elasticity and higher elongation do not contribute to the flexural strengths.

③ Asbestos:

It is a mineral fibre whose tensile strength varies between 560 to 980 N/mm². Asbestos cement has considerably higher flexural strength than portland cement paste.

Corrosion:

Corrosion is defined as the destruction of materials due to chemical reaction with the environment, and also the loss of steel due to the formation of rust. The corrosion of steel reinforcement is the depassivation of steel with the reduction in concrete alkalinity through carbonation

Corrosion deteriorates concrete because the product of the corrosion ferric oxide, brown in colour occupies a greater volume than steel and exerts substantial bursting stresses on the surrounding concrete.

The outward manifestations of rusting include staining, cracking, and spalling of concrete.

Factors influencing Corrosion:

* pH value
* Carbonation of concrete
* Reaction with chloride
* Moisture
* Oxygen
* Ambient Temperature and Relative humidity
* Severity of Exposure
* Quality of construction material
* Quality of concrete
* cover to the reinforcement
* Initial curing conditions
* Formation of Cracks.

Damages Caused by Corrosion :

* Formation of white patches.
* Brown patches along reinforcement
* Occurance of cracks
* Formation of multiple cracks
* Spalling of cover concrete
* Snapping of Bars.
* Buckling of bars and bulging of concrete

Preventive Measures in New constructions :

* **Design factors :**

Corrosion engineering principles are based on the following factors :

* low w/c ratio
* high strength concrete
* higher minimum cement content
* thicker concrete cover
* Proper detailing of reinforcement, and moderate stress levels.

* Construction Aspects :

- Adequate compaction of concrete
- Effective curing
- Production of impervious concrete
- Effective Grouting of tendons
- Periodical maintenance must be implemented

* Reinforcement Protection :

- Cement - blazed coatings
- Galvanizing / zinc - based paints
- Epoxy coating
- Bitumen, phosphate coatings

* Surface coating for Concrete :

The surface coating materials used are bitumens, elastomers, polymers, Silicones, Silanes and vegetable oils. These are used according to the properties mentioned below.

* Control Carbonation of Concrete
* Resist Chloride penetration
* Control moisture penetration of Concrete
* Provide supplementary protection in case of inadequate covers

Specifications:

* Probe diameter = 50 mm (approx)
* Minimum capacity of hydraulic apparatus = 10 kN
* Coefficient of variation between individual pull-off results = 8% to 20%
* Depth of partial core = 10mm.

Calibration:

As inspection of the probe, after the test, reveals wheather or not the concrete has failure. Results from unsatisfactory failures can, therefore be discounted.

Visual Investigation:

One of the most important components of any investigation plans is the visual examination. This involves looking for and analysing cracks, spalling, and other such structural difects can be seen without digging into or scratching the surface of the structure or its elements. To aid visual examination, the following checklist can be used.

Checklist:

The information collected should necessarily include the following:

* Details 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.
* Climate conditions Prevailing and wind direction
* Signs of deterioration
* Age of building
* Details of maintenance and previous repair and retrofitting
* Reference system used to record details during visual examination.

The equipment and accessories that will help in visual examination are the following:

- Building drawing
- Layout plan
- Camera
- Binoculars
- A magnifying glass
- A flashlight
- A clipboard
- A compass, A tape recorder

2. Active :

- Change size under load
- Continuing movement and overload
- Difficult to repair - if cause not treated, a new crack next to the repaired one is common.

On the basis of the width of Cracking, cracks classified as:-

1. Fine : Generally less than 1mm
2. Medium : Between 1 & 2 mm
3. Wide : Greater than 2mm

On the basis of the depth of Cracking, Cracks are Classified as

Surface Cracks :

- local cracks on the top layer alone, mostly non-structural components.

Crack widths can be anywhere between 0.1 and 25 mm. Cracks smaller than 0.1 mm are not visible to the naked eye and, generally do not affect the structural & functional utility of the building.

- Cracking :

This is the most common visually detactable distress encountered in any building needed repair or retrofit. Cracks may be minor, as in the case of problems associated with shrinkage, or major as in structures subjected to overloading. Cracking by itself does not warrant repair. Many cracks are inevitable such as those due to shrinkage or around reinforcement in the case of reinforced brickwork. Only cracks which are wider than the acceptable limit are to be considered as a sign of distress. Cracks of smaller widths can be of aesthetic concern, and hence need cosmetic treatment such as puttywork.

Cracks can be classified based on direction and stability :

1. Dormant :
   - Do not increase in size once formed
   - Typically cracks caused by shrinkage, initial movement of supports, previous overload
   - May or may not need repair.

Spalling :

De-lamination of surface of concrete is called Spalling. It can occur due to internal stress or due to external loads. Concentrated eccentric external load can cause a highly stressed narrow compression zone, which encourages spalling. Corrosion of steel embedded in concrete can also cause spalling. Spalling may also occur due to freezing-thawing effect of entrapped water.

Staining :

Staining of concrete is caused by absorption of water, which contains materials / salts and results in leaching or drainage over other components. It is aesthetically unpleasant. Efflorescence is a major cause of staining. Efflorescence is the process of deposition of water-soluble salts on the surface of masonry or concrete as the water carrying these salts evaporates.

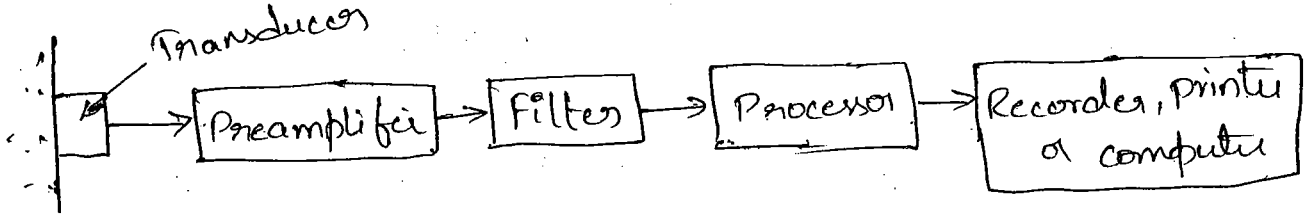
Acoustic Emission Method :

On certain materials the change of condition can occur, which causes emission of sound waves due to thermal, mechanical, or other effects. The change of condition can be a fracture, crack formation, crack growth

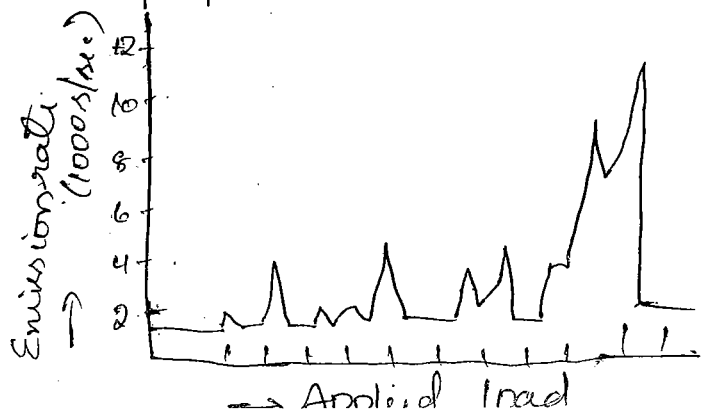
a metallurgical change such as plastic deformation, dislocation and change in crystal structure. During such changes in the condition, energy released propagates in the surrounding material as elastic vibrations These vibrations or sound waves can be detected by placing a sensor on the surface of the material.

Acoustic emission (AE) sensors are in principle high-frequency microphones, which are glued or fixed in some other manner to the clean surface so that the best possible acoustic contact is achieved.

The AE method can only detect changes in material and the defects already present cannot be revealed through this method. This method is a supplement to other non-destructive techniques. The signal detected by the piezo-electric transducer is amplified, filtered, processed and recorded in some convenient form



Results are plotted on graph:



* Protect concrete from sulphate attack.
* Protect reinforcement from corrosion.
* Water vapour diffusion resistance
* weather resistance
* Carbondioxide diffuse resistance.

Chloride attack:

Chloride attack is one of the most important aspects for consideration when we deal with durability of concrete as it primary causes corrosion. Statistics have indicated that 40% failure of structure is due to corrosion of reinforcement

Due to the high alkalinity nature of concrete a passivating film is formed on the surface of steel reinforcement. The protective passivating film can be lost due to carbonation and chloride content also, in Presence of water and oxygen.

Chloride enters the concrete from cement, water aggregates, admixtures and it can also enter the concrete by diffusion from environment

S.No	Type of use of concrete	Maximum total acid soluble chloride content (kg/m³)
1.	Concrete containing metal and steam cured at elevated temp & prestressed concrete	0.4
2.	Rcc or Pcc containing embedded metal	0.6
3.	Concrete not contain embedded metal	3.0

Prevention of corrosion lies in controlling the ingress chlorides by thickness of cover to reinforcement and by material of good quality of concrete with low w/c to decrease the penetrationability of chloride ions.

$< 0.2\%$ by weight of cement = No risk of corrosion

$0.2 - 0.4\%$ by " " " = low risk of corrosion

$0.4 - 1.0\%$ by " " = moderate " "

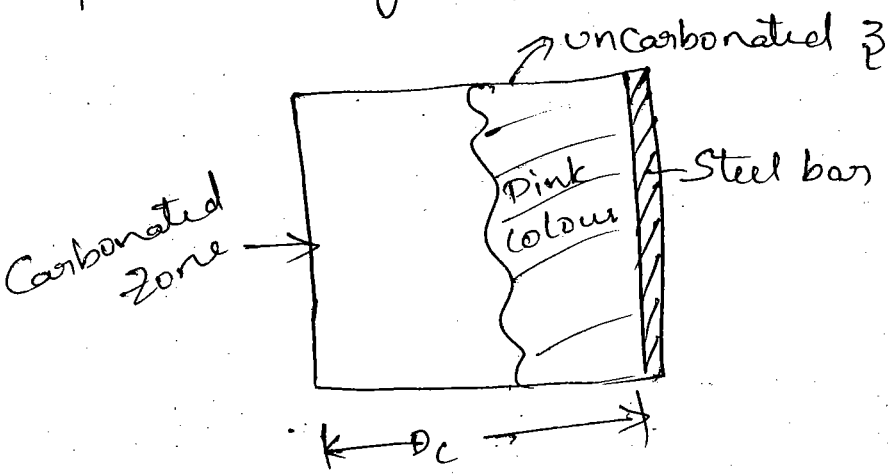
$> 1.0\%$ " " = high " "

Depth of Carbonation :

The carbonation attack in concrete is calculated in terms of depth.

Measurement :

* Carbonation is measured by using phenapthalein solution.
* when phenapthalein is sprayed on test concrete
* The carbonated zone remains same, while uncarbona-ted zone turns pink. This is because phenapthalein turns pink in high alkalinity condition.



Factors influencing Carbonation :

1. Level of water in pores :

(a) when the pore is completely filled with water, CO_2 diffuses slowly and it takes time to react, hence, carbonation less.

(b) When the concrete is completely dry, CO_2 remains gaseous and does not react. Hence, carbonation less Carbonation is more when humidity 50-70%.

② Depth of Cover :

If depth of cover is more, time to reach Carbonation till reinforcement is more

depth of cover more, Carbonation effect less on concrete.

③ Grade of concrete :

Grade of concrete more, Carbonation effect less.

④ Time of Exposure :

Time is more, Carbonation effect is less.

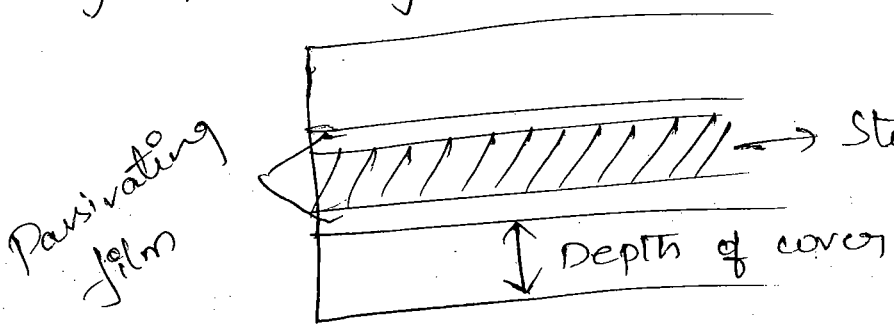
⑤ Protected / unprotected concrete :

For same depth of cover, same grade of concrete, for same time Carbonation effect is more in unprotected compared to protected concrete.

Effects of Carbonation :

Concrete is generally alkaline in nature. This alkaline nature generates protective film called

Passivating film around steel and it prevents the entry of oxygen & water to reach steel and there by preventing corrosion.



When carbonation occurs the P_H get reduced and the alkalinity get reduced, this causes the destruction of Passivating film and water & oxygen reaches it and causes rust.

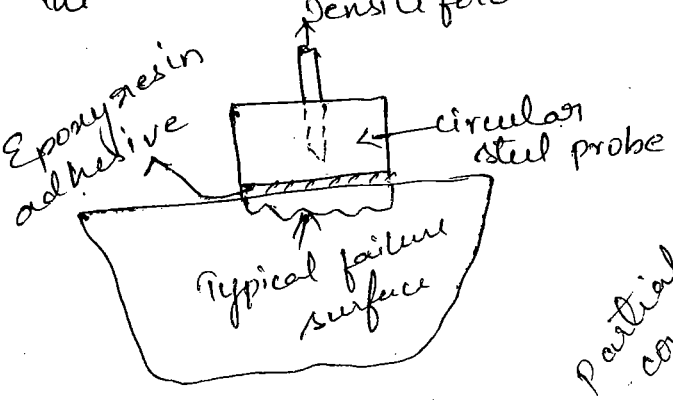
- whenever rust occurs steel volume is increased by 5%. It causes cracks and finally concrete get deteriorated.

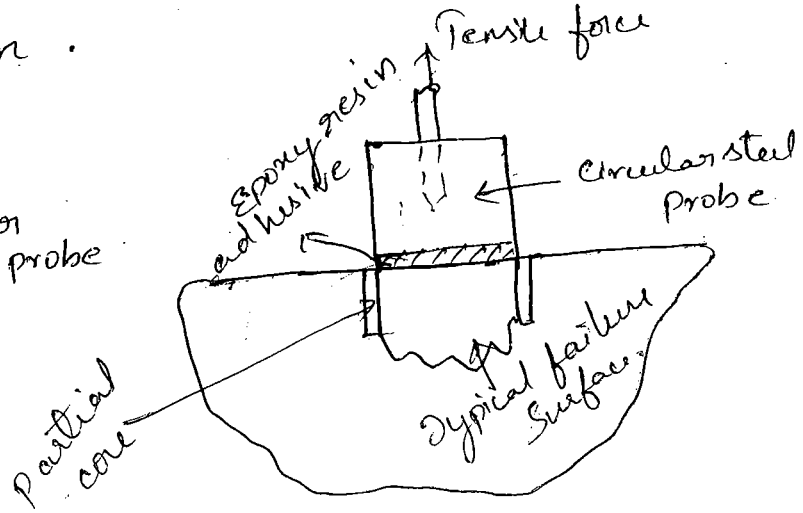
Preventive Measures:

- By applying coatings to steel (paints)
- By applied coatings to concrete
- High strength concrete
- Increasing depth of cover.

Pull-out Test :

This method actually measures the nominal tensile strength of concrete, which is correlated with the compressive strength of concrete. A circular steel probe is bounded to the surface of concrete by means of an epoxy resin adhesive. Before this operation, the surface is roughened with the help of sandpaper to remove laitance and then degreased with the help of solvent. After sufficient time has elapsed for the epoxy resin adhesive to cure, a slowly increasing tensile force is applied to the probe. And as the tensile strength of the bond is greater than that of concrete, the latter eventually fails in tension. The amount of overbreak is usually small so that the area of failure can be taken as being equal to that of the probe. From this area and the force applied at failure it is possible to calculate a nominal tensile strength of the concrete specimen.





Crack width & measurement :

According to IS 456 of 2000, If w/l surface width of the crack is less than 0.3mm, it is not harmful and does not have any serious effect on durability of concrete.

In members cracking of tensile zone is harmful either because they are exposed to the effects of weather or moisture or in contact with soil. An upper limit of 0.2 mm is suggested for max width of crack

FIP (International prestressing federation) Recommend the max crack width at the main reinforcement should be 0.004 times the nominal cover

The crack width is measured by using crack detection microscope, Digital crack measuring gauge