•Cement paste normally provides a highly alkaline environment that protects embedded steel against corrosion.

• Concrete with a low water/cement ratio, well compacted and well cured, has a low permeability and hence minimizes the penetration of atmospheric moisture as well as other components such as oxygen, chloride ion, carbon dioxide and water, which encourage corrosion of steel bar.

•In very aggressive environments, the bars may be coated with special materials developed for this purpose.

•Coating on reinforcing steel, therefore, serves as a means of isolating the steel from the surrounding environment.

•Common metallic coatings contain galvanizing zinc. High chloride concentration around the embedded steel corrodes the zinc coating, followed by corrosion of steel.

•Hence, this treatment used for moderately aggressive environments.

•For high corrosive atmospheres caused by chloride ions from the de-icing salts applied to protect against sodium chloride and calcium chloride, usually near seashores, epoxy coating is applied to protect steel reinforcing bars from corrosion.

•Such bars have acceptable bond and creep characteristics.

•The coat normally applied is 150 um thick. The reinforcement is epoxied in the factory itself, where the steel rods are manufactured.

•Such reinforcements are known as fusion-bonded epoxy coated steel.

•Steel manufacturers also manufacture Cold Twisted Deformed (CTD) bars with better corrosion resistance, termed as Corrosion Resistance Steel (CRS).

•The performance of the CRS CTD bars is better in resisting corrosion compared to plain CTD bars.

•However, the use of CRS CTD bars will only delay the process of corrosion. It will not prevent corrosion once for all.

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These are generally of two types,

•Resins blended with organic solvents and

•Solvent free coating

•Solvent-based coatings are subdivided into single and two component coatings.

•The coatings on drying produce a smooth dense continuous film that provides a barrier to moisture and mild chemical attack of the concrete.

•Because of the resistance to moisture penetration, staining, and ease of cleaning, they are preferred for locations of high humidity and those in which a lot of soiling occurs.

•Most products are low solids content materials which require multiple coats to produce a continuous film over concrete, since the materials are thermoplastic, and have a significant degree of extensibility they are capable of bridging minor cracks which may develop in the concrete surface if they are applied in sufficient thickness.

•The number of coats required depends on the surface texture, porosity and the targeted dry film thickness.

•Although some of the newer products have some moisture tolerance, enabling them to be applied over damp surfaces, in normal usage they should be applied over dry surfaces.

•Due to their relative in permeability to water vapour, they could blister when applied to concrete surfaces with high moisture content or where the opposite surface of the concrete is in constant contact with moisture.

•Careful control of wet film thickness is therefore necessary during application.

•Two component polymer coatings consist of a solution of a compounded polymer with or without solvent and a reactive chemical component called the curing agent hardener or catalyst.

•The materials are usually mixed just prior to use in accordance with the manufacturer's instructions.

When using two components polymer based coatings the following items are of importance to the application of the materials.

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Most products are supplied as a kit containing the two components in the required proportions. Therefore, in order to realize the full potential of the product the correct mix ratio of the two components must be used.

To ensure a complete reaction of the two components they must be mixed thoroughly.

Some two component material require an induction period of 15 to 40 min after mixing. Therefore, such products cannot be used immediately after mixing.

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•Foam concrete, also known as Lightweight Cellular Concrete (LCC), Low Density Cellular Concrete (LDCC), and other terms is defined as a cement-based slurry, with a minimum of 20% (per volume) foam entrained into the plastic mortar.

•As mostly no coarse aggregate is used for production of foam concrete the correct term would be called mortar instead of concrete; it may be called "foamed cement" as well.

•The density of foam concrete usually varies from 400 kg/m3 to 1600 kg/m3.

•The density is normally controlled by substituting fully or part of the fine aggregate with foam.

Properties

•Foam concrete is a versatile building material with a simple production method that is relatively inexpensive compared to autoclave aerated concrete.

•Foam concrete compounds utilising fly ash in the slurry mix is cheaper still, and has less environmental impact.

•Foam concrete is produced in a variety of densities from 200 kg/m3 to 1,600 kg/m3depending on the application.

•Lighter density products may be cut into different sizes.

•While the product is considered a form of concrete (with air bubbles replacing aggregate), its high thermal and acoustical insulating qualities make it a very different application than conventional concrete.

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Applications

bridge approaches / embankments

pipeline Abandonment / annular fill

trench backfill

precast blocks

precast wall elements / panels

cast-in-situ / cast-in-place walls

insulating compensation laying

sunken portion filling

trench reinstatement

sub-base in highways

filling of hollow blocks

prefabricated insulation boards

Advantages of foam concrete

It imposes little vertical stress on the surrounding sub-structure.

It has low thermal conductivity and good sound insulation properties which are not available in ordinary concrete.

It has excellent freeze and thaws resistance.

Foam concrete is a free-flowing concrete and can be placed without compaction.

When placing in foundation or excavations, foam concrete conforms to every subgrade contour.

Foam concrete can be pumped easily with relatively low pressure over a long distance.

Foam concrete is very long-lived material. It does not decompose and it is as durable as rock.

Foam concrete has a low coefficient of permeability.

Disadvantages

With a decrease in the density of foam concrete, its compressive and flexural strength decrease.

Foam concrete has a relatively high paste content and no coarse aggregate, it will shrink more than normal concrete.

Since it has higher cement content than normal concrete. So it becomes costly.

The durability of foam concrete mainly influenced by the ratio of the connected pore to total pore.

Mixing time of foam concrete is longer.

If a sufficient portion of concrete is removed, it can best be replaced with concrete placed in foams. This concrete can be placed without a bonding agent and without grout on the prepared surface of the old concrete. US Bureau of reclamation suggests that this method should be used

When the depth of the repair exceeds 150 mm,

For holes extending right though the concrete section

For holes in unreinforced concrete with area greater than 0.1m2 and over 100 mm deep, and

For holes in reinforced concrete which have an area greater than 0.05m2 and which extend deeper than the reinforcement.

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There are some essential requirements that apply to the use of foamed concrete as a replacement material, regardless of its location in the structure.

1. The concrete should be made from the best possible materials and with the lowest possible water/cement ratio.
2. To keep shrinkage to a minimum, the aggregate size should be large as can be accommodated and the water content as low as possible.
3. The mix should be designed so that no bleeding occurs in order to ensure that the replacement material remains in intimate contact with old concrete located above it.
4. The hole to be filled must be shaped so that there are no feather edges and with a depth normal to the finished surface of at least 40 mm.
5. Foams must be robust and firmly fixed so that they withstand any applied pressure and do not allow grout leakage.
6. Old concrete, against which new concrete is to be placed, must be sound, completely clean and saturated and the surface must be free from moisture.

•Dry packing is the hand placement of a low W/C ratio mortar which is subsequently rammed in to place to produce a dense mortar plug having tight contact to the existing concrete.

•Because of the low W/C ratio, there is a patch remains little shrinkage and the patch remains tight, with good durability, strength and water tightness.

•Dry pack should be used for filling holes having a depth equal to, or greater than, the least surface dimension of the repair area; for cone bolt, she bolt, core holes and grout-insert holes; for holes left by the removal of form ties; and for narrow slots cut for repair of cracks.

•Dry pack should not be used for relatively shallow depressions where lateral restraint cannot be obtained, for filling behind reinforcement, or for filling holes that extend completely through a concrete section.

•For the dry pack method of concrete repair, holes should be sharp and square at the surface edges, but corners within the holes should be rounded, especially when water tightness is required.

•The interior surfaces of holes left by cone bolts and she bolts should be roughened to develop an effective bond; this can be done with a rough stub of 7/8-inch steel wire rope, a notched tapered reamer, or a star drill.

•Other holes should be undercut slightly in several places around the perimeter.

•Holes for dry pack should have a minimum depth of 1 inch.

•All the water used in mixing concrete is not required for hydration.

•Therefore, removal of excess water before hardening take place improves concrete strength.

•Vacuum concrete is the type of concrete in which the excess water is removed for improving concrete strength.

•The water is removed by use of vacuum mats connected to a vacuum pump.

Advantages

•The final strength of concrete is increased by about 25%.

•Sufficient decrease in the permeability of concrete.

•Vacuum concrete stiffens very rapidly so that the form-works can be removed within 30 minutes of casting even on columns of 20 ft. high.

•This is of considerable economic value, particularly in a precast factory as the forms can be reused at frequent intervals.

•The bond strength of vacuum concrete is about 20% higher.

•The density of vacuum concrete is higher.

•It bonds well to old concrete and can, therefore, be used for resurfacing road slabs and other repair works.

Disadvantages

•They need specific equipment.

•This needs trained labour.

•They need power connection.

•They have a high initial cost.

•The porosity of concrete allows water, oil, and grease to seep though consequently weakening the concrete.

•It is well known that high water/cement ratio is harmful to the overall quality of concrete, whereas low water/cement ratio does not give enough workability for concrete to be compacted hundred percentage.

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

•Vacuum process of concreting enables to meet this conflicting demand.

•This process helps a high workable concrete to get high strength.

•In this process, excess water used for higher workability, not required for hydration and harmful in many ways to the hardened concrete is withdrawn by means of vacuum pump, subsequent to the placing of the concrete.

•The process when properly applied produces concrete of quality. It also permits removal of formwork at an early age to be used in other repetitive work.

•It essentially consists of a vacuum pump, water separator and filtering mat.

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

•A sheet of expanded metal and then a sheet of wire gauge also form part of the filtering mat.

•The top of the suction mat is connected to the vacuum pump.

•When the vacuum pump operates, suction is created within the boundary of the suction mat and the excess of water is sucked from the concrete through the fine wire gauge or muslin cloth.

•At least one face of the concrete must be open to the atmosphere to create difference of pressure.

•The contraction of concrete caused by loss of water must be vibrated.

•The vacuum processing can be carried out either from the top surface or from the side surface.

•There will be only nominal difference in the efficiency of top processing or side processing.

• It has been seen that the size of the mat should not be less than 90 cm X 60 cm. Smaller mat was not found to be effective.

Rate of extraction of water

The rate of extraction of water is depends on workability of mix, maximum size of aggregate, proportion of fines and aggregate, cement ratio.

The following general tendencies are observed.

The amount of water, which may be withdrawn, is governed by the initial workability or the amount of free water. A great reduction in the water/cement ratio can, therefore, be obtained with higher initial water/cement ratio.

If the initial water/cement ratio is kept the same, the amount of water which can be extracted is increased by increasing the maximum aggregate size or reducing the amount of fines in the mix.

The reduction in the water/cement ratio is very slightly less with mixes leaner than 6 to1, but little advantage is gained with mixes richer than this.

The greater the depth of concrete processed the smaller is the depression of the average water/cement ratio.

The ability of the concrete to stand up immediately after processing is improved if a fair amount of fine material is present, if the maximum aggregate size is restricted to 19 mm and if a continuous grading is employed.

Little advantage is gained by prolonging the period of treatment beyond 15 to 20 minutes and a period of 30 minutes is the maximum that should be used.



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

•Recently this method has been further developed by the introduction of small sized coarse aggregate into the mix deposited to obtain considerably greater thickness in one operation and to make the process economical by reducing the cement content.

•Normally fresh material with zero slump can support itself without sagging or peeling off.

•The force of the jet impacting on the surface compact the material.

•Sometimes use of set accelerators to assist overhead placing is practiced.

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•The newly developed “Rediset cement” can also be used for shotcreting process.

•There is not much difference between guniting and shotcreting.

•Gunite was first used in the early 1900 and this process is mostly used for pneumatical application of mortar of less thickness, whereas shotcrete is a recent development on the similar principle of guniting for achieving greater thickness with small coarse aggregates.

There are two different processes in use, namely the ‘Wet-mix” process and the ‘dry-mix”

process. They dry mix process is more successful and generally used.

Dry-mix process

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

typical plant set-up is shown in Fig

The stages involved in the dry mix process is given below :

(a) Cement and sand are thoroughly mixed.

(b) The cement/sand mixture is fed into a special air-pressurized mechanical feeder termed as

“gun”.

(c) The mixture is metered into the delivery hose by a feed wheel or distributor within the

gun.

(d) This material is carried by compressed air through the delivery hose to a special nozzle.

The nozzle is fitted inside with a perforated manifold through which water is sprayed under

pressure and intimately mixed with the sand/cement jet.

(e) The wet mortar is jetted from the nozzle at high velocity onto the surface to be gunited.

The Wet-mix Process

In the Wet-mix process the concrete is mixed with water as for ordinary concrete before conveying through the delivery pipe line to the nozzle, at which point it is jetted by compressedzair, onto the work in the same way, as that of dry mix process.

The wet-mix process has been generally discarded in favors of the dry-mix-process, owing to the greater success of the latter. The dry-mix methods make use of high velocity or low velocity system. The high velocity gunite is produced by using a small nozzle and a high air pressure to produce a high nozzle velocity of about 90 to 120 metres per second. This results in exceptional good compaction. The lower velocity gunite is produced using large diameter hose for large for large output. The compunction will not be very high.

**Advantages of Wet and Dry process**

**S**ome of the advantages and disadvantages of the wet and dry processes is discussed below.

Although it is possible to obtain more accurate control of the water/cement ratio with the wet process the fact that this ratio can be kept very low with the dry process largely overcomes the objection of the lack of accurate control.

The difficulty of pumping light-weight aggregate concrete makes dry process more suitable when this type of aggregate is used. The dry process on the other hand, is vey sensitive to the water content of the sand, too wet a sand causes difficulties through blockade of the delivery pipeline, a difficulty which does not arise with the wet process. The lower water/cement ratio obtained with the dry process probably accounts for the lesser creep and greater durability of concrete produced in this way compared with concrete deposited by the wet process, but air-entraining agents can be use to improve the durability of concrete deposited by the latter means. Admixtures generally can be used more easily with the wet process except for accelerators.

Pockets of lean mix and of rebound can occur with the dry process. It is necessary for the Nozzel man to have an area where he can dump unsatisfactory shotcrete obtained when he is adjusting the water supply or when he is having trouble with the equipment.

These troubles and the dust hazard are less with the wet process, but wet process does not normally give such a dense concrete as the dry process. Work can be continued in more windy weather with the wet process than with the dry process. Owing to the high capacities obtainable with concrete pumps, a higher rate of laying of concrete can probably be achieved in the wet process than with

the dry process.

•The Injection of polymer under pressure will ensure that the sealant penetrates to the full depth of the crack.

•The technique in general consists of drilling hole at close intervals along the length of cracks and injecting the epoxy under pressure in each hole in turn until it starts to flow out of the next one.

•The hole in use is then sealed off and injection is started at the next hole and so on until full length of the crack has been treated.

•Before injecting the sealant, it is necessary to seal the crack at surface between the holes with rapid curing resin.

•For repairs of cracks in massive structures, a series of holes (Usually 20 mm in dia and 20mm deep spaced at 150 to 300mm interval) intercepting the crack at a number of location are drilled.

•Epoxy injection can be used to bond the cracks as narrow as 0.05mm.

•It has been successfully used in the repair of cracks in buildings, bridges, dams and other similar structures.

•However, unless the cause of cracking is removed, cracks will probably recur possibly somewhere else in the structure.

•Moreover, in general this technique is not very effective if the cracks are actively leaking and cannot be dried out.

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Epoxy injection is a highly specialized job requiring a high degree of skill for satisfactory execution. The general steps involved are as follows.

**Preparation of the surface:**

The contaminated cracks are cleaned by removing all oil, grease, dirt and fine particles of concrete which prevent the epoxy penetration and bonding.

The contaminants should preferably be removed by flushing the surface with water or a solvent.

The solvent is then blown out using compressed air, or by air drying. The surface cracks should be sealed to keep the epoxy from leaking out before it has cured or gelled.

A surface can be sealed by brushing an epoxy along, the surface of cracks and allowing it to harden.

If extremely high injection pressures are needed, the crack should be routed to a depth of about 12mm and width of about 20mm in V-shape, filled with an epoxy, and stuck off flush with the surface.

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**Installation of entry ports:**

The entry port or nipple is an opening to allow the injection of adhesive directly into the crack without leaking.

The spacing of injection ports depends upon a number of factors such as depth of crack, width or crack and its variation with depth, viscosity of epoxy, injection pressure etc. and choice must be based on experience.

In case of V-grooving of the cracks, a hole of 20 mm dia and 12 to 25 mm below the apex of V-grooved section, is drilled into the crack.

In case the cracks are not V-grooved, the entry port is provided by bonding a fitting, having a hat-like cross-section with an opening at the top for adhesive to enter, flush with the concrete face over the crack.

**Mixing of epoxy:**

The mixing can be done either by batch or continuous methods. In batch mixing, the adhesive components are premixed in specified proportions with a mechanical stirrer, in amounts that can be used prior to the commencement of curing of the material.

With the curing of material, pressure injection becomes more and more difficult.

In the continuous mixing system, the two liquid adhesive components pass through metering and driving pumps prior to passing through an automatic mixing head.

The continuous mixing system allows the use of fast-setting adhesives that have short working life.

**Injection of epoxy:**

In its simplest form, the injection equipment consists of a small reservoir or funnel attached to a length of flexible tubing, so as to provide a gravity head.

For small quantities of repair material small hand-held guns are usually the most economical.

They can maintain a steady pressure which reduces chances of damage to the surface seal.

For big jobs power-driven pumps are often used for injection. The pressure used for injection must be carefully selected, as the use of excessive pressure can propagate the existing cracks, causing additional damage.

The injection pressures are governed by the width and depth of cracks and the viscosity of resin and should not exceed 0.10MPa.

•It is preferable to inject fine cracks under low pressure in order to allow the material to be drawn into the concrete by capillary action and it is a common practice to increase the injection pressure during the course of work to overcome the increase in resistance against flow as crack is filled with material.

•For relatively wide cracks gravity head of few hundred millimetres may be enough.

**Removal of surface seal:**

After the injected epoxy has occurred; the surface seal may be removed by grinding or other means as appropriate.

 Fittings and holes at the entry ports should be painted with an epoxy patching compound.

**Mortar repair for cracks**

Portland cement mortar may be used for repairing defects on surfaces not prominently exposed. where the defects are too wide for dry-pack filling or where the defects are too shallow for concrete filling, and no deeper than the far side of the reinforcement that is nearest the surface. repairs may be made either by use of shotcrete or by hand application methods, although hand application methods are generally recommended for areas subject to public view in historic preservation applications.

Replacement mortar can be used to make shallow, small-size repairs to new or green concrete, provided that the repairs are performed within 24 hours of removing the concrete forms. Accomplishing successful mortar repairs to old concrete without the use of a bonding resin is unlikely or extremely difficult. Evaporative loss of water from the surface of the repair mortar, combined with capillary water loss to the old concrete, results in unhydrated or poorly hydrated

cement in the mortar. Additionally, repair mortar bond strength development proceeds at a slower rate than compressive strength development. This causes workers to mistakenly abandon curing procedure prematurely, when the mortar seems strong. Once the mortar dries, bond strength development stops, and bond

failure of the mortar patch results. For these reasons using cement mortar without a resin bond coat to repair old concrete is discouraged. A Portland cement mortar patch is usually darker than the surrounding concrete unless precautions are taken to match colours. A leaner mix will usually produce a lighter colour patch.

**Preparation and materials**

Concrete to repaired with replacement mortar should first have all the deteriorated or unsound areas removed. After preparation, the areas should be cleaned, roughened if necessary and surfacedried to a saturated surface condition. The mortar should be applied immediately thereafter. Replacement mortar contains water, Portland cement and sand. The water and sand should be suitable for use in concrete, and the same should pass through a no.16 sieves. Only enough water

should be added to the cement sand mixture to permit placing.

**Curing**

Failure to cure properly is the most common cause of failure of replacement mortar.It is essential that mortar repairs receive a through water cure starting immediately after initial set and continuing for 14 days. In no event should the mortar be allowed to become dry during the 14 day period following placement. Following the 14 day water cure and while the mortar is still

saturated, the surface of the mortar should be coated with two coats of a wax-base curing compound meeting reclamation specifications.

**Applications**

The success of this method depends on complete removal of all defective and affected concrete, good bonding of the mortar to the concrete, elimination of shrinkage of the patch after placement, and thorough curing. Replacement mortar repairs can be made using an epoxy bonding agent; this technique is highly recommended.

Providing support to get stability of a structure  temporarily under certain circumstances during construction, repair or alteration.

Such circumstance arises when

The stability of a structure is endangered due to removal of a  defective portion of the structure.

The stability of a structure is endangered due to unequal settlement during construction itself or in long run.

Certain alterations are to be done in present structure itself. Eg:  remodeling of walls, changing position of windows etc.

Alterations are carried out in adjacent building for remodeling, strengthening of foundation, etc.

For shoring, timber or steel tubes may be used. Sometimes both are  used in combination. If timber is used its surface should be coated  with a preservative so as to protect against wet rot.

The shoring should be designed based on the load it has to sustain  and duration of load.

Shoring may be given internally or externally depending on the  case and in certain cases they may be provided on either side of  the wall to produce additional stability.

Shoring should be installed only after getting the permission if  necessary, of the local authorities.

There is no time limit to which the shoring has to be kept, it may  range from weeks to years depending on the case.

**Types**

Raking or inclined shores

Flying or horizontal shores

Dead or vertical shores

**Underpinning**

•It is the method of supporting the structures while providing new  foundations or carrying out repairs and alterations without  disturbing the stability of existing structures. It is carried under  following conditions:

When a building with deep foundation is to be constructed  adjoining a building which is built on shallow footings. Here the  shallow footings should be strengthened first.

In order to protect an existing structure from the danger of excessive or differential settlement of foundation.

In order to improve the bearing capacity of foundation so as to  sustain heavier loads for which deepening or widening of  foundation is done.

In order to provide a basement for an existing structure.

Precautionary measures

Before implementing appropriate underpinning measures the  following important points should be carefully attended:

The existing structure should be fully examined carefully and  appropriate underpinning method should be adopted.

All poor masonry work, such as joints, cracks, plastering  should be rectified before.

Necessary shoring and strutting should be done such that  existing structure is safe.

Urgent repair like grouting of cracks, insertion of rod  between walls , etc. should be carried out before  commencing underpinning.

Adequate care should be taken to ensure that there should be  no movement of structure for which levels should be marked.

Underpinning process is not a science but an art should be  exercised depending on the situation.

**Methods of underpinning**

Pit method

Pile method

Chemical mOther method

ethod

**Chemical method**

In this method the foundation soil is consolidated by  employing chemicals.

Perforated pipes are driven in an inclined direction beneath  the foundation . The slopes are provided such that the entire  area under the existing footing comes under the area used to  be strengthened.

After the pipes are installed, solution of sodium silicate in  water is injected through the pipes. This is a two-injection  method. The pipes are withdrawn and at the time of  withdrawal of pipes, calcium or magnesium chloride is  injected through pipes.

Chemical reaction takes place between these two chemicals  and the soil is strengthened by consolidation. This method is  suitable for granular soils.

•Corrosion of steel reinforcement occurs by a electrochemical process which involves exchanges of electrons similar to that which occurs in a battery.

•The important part of the mechanism is the separation of negatively charged areas of metal or “anodes” where corrosion occurs and positively charged areas or “cathodes” where a harmless charge balancing reaction occurs.

•At the anode the iron dissolves and then reacts to form the solid corrosion product, rust.

•The rust is formed at the metal/oxide interface, forcing previously formed oxide away from the steel and compressing the concrete, causing it to spall.

There are two major situations in which corrosion of reinforcing steel can occur.

These include:

1. Carbonation,

2. Chloride contamination

**Deterioration through Carbonation**

•Carbonation is a process in which carbon dioxide from the atmosphere diffuses through the porous concrete and neutralizes the alkalinity of concrete.

Ca(OH)2+CO2  CaCO3+H2O

•Carbon dioxide, which is present in air in proportions of around 0.3 percent by volume, dissolves in water to form a mildly acidic solution.

•Unlike other acids that may chemically attack and etch the surface of the concrete, this acid forms within the pores of the concrete itself where the carbon dioxide dissolves in any moisture present.

•Here it reacts with the alkaline calcium hydroxide forming insoluble calcium carbonate.

•The pH value then drops from 12.5 to about 8.5. The carbonation process moves as a front through the concrete, with a pH drop across the front.

•When it reaches the reinforcing steel, the passive layer decays when the pH value drops below 10.5. The steel is then exposed to moisture and oxygen and is susceptible to corrosion.

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•Concrete inside the building frequently carbonates totally without any sign of deterioration as the concrete dries out, leaving the steel exposed to air but not moisture.

•Problems are seen externally where concrete is exposed to the elements and in certain situations internally, such as kitchens and bathrooms, where the concrete is susceptible to condensation or water- leakage.

**Deterioration due to chlorides**

•Salt causes corrosion by a different mechanism. When salt is dissolved in water sodium chloride forms a versatile, highly corrosive solution of sodium ions (Na+) and chloride ions(Cl-).

•Salt is used for de-icing roads and its presence in sea water is a major problem for reinforced concrete structures.

•The very mobile chloride ions disperse through concrete pores in solution and where they come into contact with the reinforcing steel they attack the passive layer.

•Steel oxidizes in the presence of air and water to form rust which has a volume of up to 10 times that of the steel consumed.

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•As concrete has low tensile strength it will crack when as little as a tenth of a millimetre of steel has been consumed.

•Horizontal cracks from, causing corners to “SPALL” and surfaces to “delaminate” as the reinforcement's concrete cover becomes detached and falls away in sheets.

•The consequence can be seen on the underside of road bridges and many buildings and structures beside the sea.

ACI recommends the following chloride limits in concrete for new construction, expressed as a percent by weight of cement:

vPre-stressed concrete 0.08%

vReinforced concrete in wet conditions 0.10%

vReinforced concrete in dry conditions 0.20%

vBut in existing structures 0.026% is enough to breakdown the Passive Layer.

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•Various factors initiate and sustain the process of corrosion in R.C. structures. They are broadly divided into two groups:

üGeneral Influencing factors

üGeneral accelerating factors

The following are the factors that generally influence corrosion of reinforcement in R.C. structures.

•pH Value

•Moisture

•Oxygen

•Carbonation

•Chlorides

•Ambient temperature

•Severity of exposure

•Quality of concrete

• Cover to the reinforcement

• Initial curing condition

•Formation of cracks

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The following are the factors which accelerates the process of corrosion in R.C. structures

•Chlorides

•Sulphates

•Chlorine

•Electrical Charges

•Methane Acids

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•The following are some of the methods for protecting steel from corrosion

ØProtective coatings for reinforcement

ØCathodic protection

ØCorrosion Resistant steel

ØCorrosion inhibitors

**Protective coatings for reinforcement**

•This is an effective means to combat corrosion in such environment where ordinary concrete with surface coating is not able to protect reinforcement against corrosion.

•The surface coating for the reinforcement will increase the protection against corrosion.

•There are several methods of providing protective coating to the reinforcement. The important ones are:

**Cement Slurry Coating**

ØCement Slurry Coating provides short-term protection until placement in concrete.

ØSeveral methods have been developed for an effective corrosion protection using cement slurry.

ØOne such coating is a mixture of cement, condensed silica and polymer dispersion.

ØThis mixer found to be impermeable to water, chlorides and carbon-di-oxide.

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Epoxy coating

•Epoxy coating is formed by application of an epoxy resin with appropriate curing agents catalysts, pigments and flow control agents.

•Fusion bonding using the electrostatic process is the recent development.

•Fusion bonded epoxy coating provides long-term protection against corrosion.

•Though the cost is relatively high, it is the one which is the most effective in high alkaline and chloride contaminated environment.

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Plastic coating

•Similar to epoxy coating, the plastic coatings are very effective in preventing corrosion of reinforcement even in high alkaline or chloride contaminated environment.

•However, the reduction in bond between plastic coated bar and the concrete is quite substantial and hence plastic coating cannot be considered as a solution for prevention of corrosion which cannot be solved by conventional methods.

**Galvanizing**

•Galvanizing gives protection to the reinforcement against corrosion, by means of metallic coating such as zinc.

•However, in case of corrosion due to excessive chlorides, the effect of galvanizing protection is reduce and hence is not advisable in highly chloride contaminated environments.

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Cathodic protection

•Cathodic protection interferes with the natural action of the electrochemical cells that are responsible for corrosion.

•Cathodic protection can be effectively applied to control corrosion of surfaces that are immersed in water or exposed to soil.

•Cathodic protection in its classical form cannot be used to protect surfaces exposed to the atmosphere.

•The use of anodic metallic coatings such as zinc on steel (galvanizing) is, however, a form of cathodic protection, which is effective in the atmosphere.

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There are two basic methods of supplying the electrical currents required to interfere with the electrochemical cell action. They are

1. Cathodic protection with galvanic anodes.

2. Impressed current cathodic protection

**Cathodic protection with galvanic anodes**

•Cathodic protection (CP) is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell.

•This is achieved by placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell.

•This method is also called sacrificial anode cathodic protection system, where the active metal is consumed in the process of protecting the surfaces, so that corrosion is controlled.

•In sacrificial anode systems the high energy electrons required for cathodic protection are supplied by the corrosion of an active metal.

•Sacrificial anode systems depend on the differences in corrosion potential that are established by the corrosion reactions that occur on different metals or alloys.

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**Corrosion inhibitors**

•Corrosion inhibitors are admixtures that either extend the time to corrosion initiation or significantly reduce the corrosion rate of embedded metal, or both, in concrete.

•There are four common type of corrosion inhibiting admixtures, and their dosage is usually dependent upon the client’s expected serviceable life of the structure and on a range of factors that affect the durability of concrete.

•These include cement type, water-to-cement ratio, cover provided b/w concrete to the steel, ambient temperature and the expected level of exposure to chlorides

•Corrosion-inhibiting admixtures are effective after the concrete has hardened and give a long-term increase in the passivation state of steel reinforcement and other embedded steel in concrete structures.

•Aggressive substances such as chloride and carbonation could jeopardize passivation layer of iron hydroxides on the steel surface and corrosion would eventually occur.

•For these reasons, admixtures that mitigate the corrosion process are useful in extending the life of concrete structures such as highways, multi-storey car parks, jetties, wharves, mooring dolphins, and sea walls.

The four most common types of corrosion inhibiting admixture are:

**1. Amine Carboxylate**

Available as concentrated liquids or powders.

They are absorbed on to the steel bars surfaces and create protective molecular layer, as shown in Figure.

The protective layer of amine carboxylate prevents further reactions between corrosive elements and embedded reinforcement, and decline existing corrosion rates.

Retard setting times 3 to 4 hours at 20°C.

Reduce chloride-induced corrosion of any good-quality concrete from seawater, salt-laden air, and de-icing salt exposure.

•Effective in corrosion reduction due to carbonation or chloride or combination thereof.

•The standard dosage rate is 0.6 to 1 L/m^3 for liquids and 0.6 kg/m^3 for powder versions.

•It can be added to concrete at concrete plant or job site as a powder.

•Compatible with pozzolans or slag, and do not affect the finishing properties of the concrete when used in combination with them.

•Adjustment to mixture design is not needed

**2. Amine-ester Organic Emulsion**

Available as a milky-white emulsion.

Creates protective layer on the steel surface and a decrease chloride permeability of the concrete

The recommended dosage is 5 L/m3 to provide effective corrosion inhibition, minimizing the impact of the inhibitor on the fresh and hardened properties of concrete such as air entrainment and compressive strength.

For severe corrosion environments, corrosion inhibitors in combination with supplementary cementitious materials, low w/c ratio  equal or less than 0.40, and adequate cover over steel.

•It is used to extend the life span of reinforced concrete structures subjected to chlorides.

•It should be blended with good quality concrete with largest w/c ratio of 0.40 and adequate concrete protection over steel bars.

•It can be used in good-quality concrete with a maximum w/c ratio of 0.40 and an appropriate level of clear cover over the reinforcing steel.

•If compressive strength reduction is unacceptable, then slight lower dosage should be used to compensate for that.

•However, mixture design adjustment is not needed when compressive strength meets design requirements.

**3. Calcium Nitrite**

Available as a 30% solution.

It is categorized as an anodic inhibitor that interferes with the chloride complexing process by oxidizing the more easily attacked form of iron to the more stable form.

High volume (30 L/m^3) of calcium nitrite is need to achieve desired results.

Calcium nitrite is appropriate to use for reducing chloride induced corrosion of any good-quality concrete, from seawater, salt-laden air, and de-icing salt exposure.

It is not applicable for poor-quality concrete or concrete with very low clear cover over the reinforcing steel.

w/c ratio of 0.40 or smaller should be used when calcium nitrite is added to concrete. However, w/c of 0.45 in combination with pozzolan or slag can be used in case of moderate design life concrete construction.

Calcium nitrite is an accelerator of both set and strength development of concrete.

Increase the strength of concrete significantly at early ages especially at 29 days.

**4. Organic Alkenyl Dicarboxylic Acid Salt**

Available as a water-based solution.

The organic alkenyl dicarboxylic acid salt is also known as DSS.

It can be classified as a dual-action corrosion inhibitor, affecting the anodic reaction at the steel and restricting moisture used in the cathodic reaction.

Dosage of 5L/m^3 is adequate for chlorides in groundwater.

For more severe exposures such as bridge decks that are salted or marine applications 10 L/m^3 is recommended.

It is also appropriate for use in reducing chloride induced corrosion of properly proportioned concrete from seawater, salt-laden air, and de-icing exposure.

Properly proportioned concrete should have a maximum w/c of 0.40 and the appropriate clear cover over the reinforcing steel.

It is found that susceptibility of mild steel to corrosion is not significantly affected by composition, grade or level of stress. Hence substitute steel for corrosion resistance must have a significantly different composition. Based on some success in atmospheric corrosion, weathering steels of the corten type were tested in concrete.

They did not perform will in moist concrete, containing chlorides. It is observed that weathering corrode in similar concrete environments, to those causing corrosion of high-yield steel. They noted that although the total amount of corrosion was less, than would occur on high-yield steel under similar conditions, deep localized pitting developed, which could be more structurally weakening.

Stainless steel reinforcement has been used in special applications, especially as fitments in precast members, but is generally too expensive to use as a substitute for mild steel. Very high corrosion resistance was shown by austenitic stainless steel in all the environments, in which they were tested, but the observations of some very minor printing in the presence of chlorides lead to the warning that crevice corrosion susceptibility was not evaluated in the test program. High titanium alloy bar is being used in some countries. This bar is grouted into holes,

drilled into the marble stabs, and the grouts are based either on Portland cement or Epoxy.

Demolition  is  the  dısmantlıng,  razıng,  destroyıng  or  wreckıng  any building  or   structure or any  part  of building by pre-planned and controlled methods.

Demolition  is  bringing  down  the  building  and  other  structures safely.

The demolition of structure with the help of explosives  is called as *implosion.*

The main objective for demolition may be the age of the  structure.

Methods of  demolition depends upon

type of structure

height and surrounding structures.

FACTORS AFFECTING SELECTION OF DEMOLITION METHOD

Type of structure

Different types of structure like load bearing masonry

structure , RCC framed structure, steel structure , etc.

oSize of structure

If the size of structure is small, hand demolition can be  sufficient. for large structures and multistoreyed buildings  special like wrecking ball method, deliberate collapse, implosion  technique etc are necessary.

oAvailable time period

oLocation of structure

oLimitation of noise, dust and vibrations

oSkill of workers

oSafety

oAvailability of equipment

oAdjacent structures

o

**Mechanical methods**

Wrecking method

Pusher arm technique

Thermic lance technique

Non explosive demolition

Concrete sawing method

Deliberate collapse method

Pressure jetting method

bursting

**Manual demolition**

It is suitable for demolition of small buildings.

Tools required for manual demolition

Hammers

Picks

Wire cutters

Welding cutters

Hand driven hydraulic jacks

**Sequence of demolition**

Prior to demolition of internal floors, all cantilevered slabs and beams, canopies, and verandahs shall first be demolished

The structural elements, in general, shall be demolished in the following sequence:

•Slabs;

•Secondary beams; then

•Main beams

Mechanical plant shall descend from the floor with temporary access ramp, or be lowered to the next day floor by lifting machinery or by other appropriate means;

When a mechanical plant has just descended from the floor above, the slabs and beams, in two consecutive floors may be demolished by the mechanical plant simultaneously. The mechanical plant may work on structural elements on the same floor and breaking up the slabs on the floor above;

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The wall panel, including beams and columns shall be demolished by gradually breaking down the concrete or by pulling them down in a controlled manner.

**Crane and Ball method**

The ball is made from forged steel,  which means the steel is not cast  into a mould in a molten state. It is  formed under very high pressure  while the steel is red hot (soft but  not molten) to compress and to  strengthen it.

Concrete members can be broken  into small pieces, but secondary  cutting of reinforcing may be  necessary.

Advantages and Disadvantages of Ball and  Crane method:

Advantages:

1)To demolish roofs and other horizontal spans.

2)The wrecking balls are still used when demolition may

not be possible due to local environmental issues or  asbestos/lead building content.

Disadvantages:

1)It demands a great deal of skill from the crane operator.

2)The height of a building that can be demolished is  limited by crane size and working room; however, buildings  as high as 20 stories have been demolished.

3)The breakup process can cause considerable dust,

vibration and noise which may be objectionable.

A thermal lance is created by packing a seamless mild steel  tube with low carbon rods and passing oxygen through the  tube.

While this method eliminates vibration and dust problems,  it creates other hazards associated with smoke and fire  danger.

Whether sawing, jetting or lancing is used to dismantle the  structure or its components, each element must be safely  lowered to the ground.

**Hydraulic breaker**

  A common piece of equipment used for demolishing  bridge decks, foundations and pavements is a  hydraulically or pneumatically operated, boom-mounted  breaker.

The advantages of a machine mounted breaker may  include a telescoping boom for easy reach and, remote  control operation and underwater demolition capabilities

Some of the smaller remote- controlled machines can be  lifted through window openings and used inside a  building to demolish floors and walls.

Productivity can vary greatly depending on hammer size, type  of  concrete,  amount  of  reinforcing  and  working  conditions.

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 A hydraulic jackhammer, typically much larger than portable  ones, may be fitted to mechanical excavators or backhoes and  is widely used for roadwork, quarrying and general demolition  or construction groundwork.

They are used  in mines where there is an  explosion risk since they lack any high-power electrical  circuitry that might cause a  triggering spark.

The jackhammer is  connected with hydraulic hoses to a portable hydraulic  power pack: either a petrol or  diesel engine driving a  hydraulic pump.

**Pressure bursting technique**

Pressure bursting can be used in cases  where relatively quiet, dust-free,  controlled demolition is preferred.

Both mechanical and chemical pressure  bursting split the concrete, either with a  splitting machine operating on hydraulic  pressure provided by a motor in the case  of mechanical bursting, or through the  insertion of an expansive slurry into a  pre-determined pattern of boreholes in  the case of chemical bursting.

The  split  concrete  is  then  easily  removed, either by hand or by crane.

Both methods work by applying lateral  forces against the inside of holes drilled  into the concrete.

**Explosive techniques**

Introduction

In the controlled demolition industry, building implosion is  the strategic placing of explosive  material and timing of its detonation so  that a structure collapses on itself in a  matter of seconds, minimizing the physical damage  to its immediate

surroundings.