Unit 4- TECHNIQUES FOR REPAIR AND DEMOLITION

Rust Eliminators

Cement paste normally provides a highly alkaline environment that projects 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 reinforcement are known as fusion-bonded epoxy coated steel. Steel manufacturers also manufacture 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.

FOAMED CONCRETE

What is foam concrete?

Foam concrete is a type of concrete made with fine aggregates, foaming material, water, cement/fly ash. Natural or synthetic foaming agents are used to produce light weight foam concrete having low density. As there are no course aggregates, foam concrete ingredients form homogeneous mixture more than normal concrete. It is also known as porous/aerated/light weight concrete.

Foam concrete is a type of porous concrete. According to its features and uses it is similar to aerated concrete. Thesynonyms are:

1) **Aerated concrete**
2) **Lightweight concrete**
3) **Porous concrete**

- Light weight concrete - or foamed concrete - is a versatile material which consists primarily of a cementbased mortar mixed with at least 20% of volume air.
- It possesses high flow ability, low self-weight, minimalconsumption of aggregate, controlled low strength and excellent thermal insulation properties.
- It can have a range of dry densities, typically from 400kg/m3 to 1600 kg/m3 and a range of compressive strengths, 1 MPa to 15 MPa .

FOAMED CONCRETE BLOCK

- Foamed Concrete can be placed easily, by pumping if necessary, and does not require compaction, vibrating orlevelling.
- It has excellent resistance to water and frost, andprovides a high level of both sound and thermal insulation.

Constituent materials

1) **Constituents of base mix**
2) **Foam**

1) Constituents of base mix

- Ordinary Portland cement, Rapid hardening Portland cement and , high alumina and Calcium Sulfoaluminate have been used for reducing the setting time and to improve the early strength of foame concrete.
- Fly ash and ground granulated blast furnace slag have been used in the range of 30–70% and 10–50%, respectively and as cement replacement to reduce the cost, enhance consistence of mix and to reduce heat of hydration while contributing towards long term strength.
- Silica fume up to 10% by mass of cement has been added to intensify the strength of cement . Alternate fine aggregates, viz., fly ash and lime, chalk and crushed concrete , recycled glass, foundry sand and were used either to reduce the density of foam concrete .

- The water requirement for a mix depends upon the composition and use of admixtures and is governed by the consistency and stability of the mix .

2) Foam

Foam concrete is produced either by :-

1) pre-foaming method
2) mixed foaming method

- Pre-foaming method comprises of producing base mix and stable preformed aqueous foam separately and then thoroughly blending foam into the base mix.
- In mixed foaming, the surface active agent is mixed along with base mix ingredients and during the process of mixing,foam is produced resulting in cellular structure in concrete .

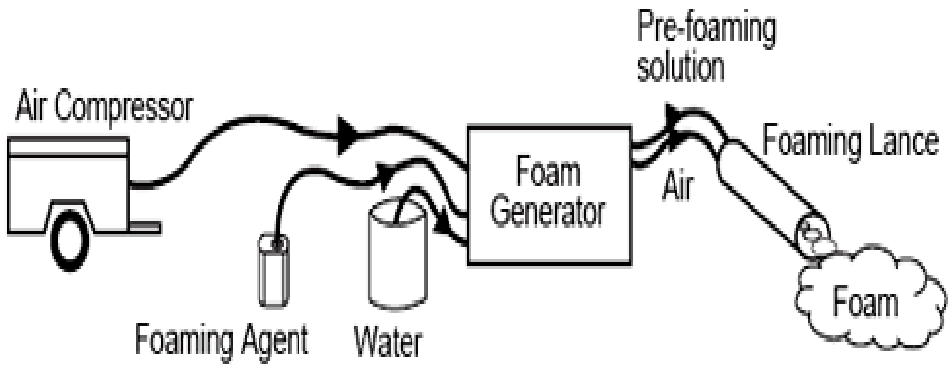
MAKING OF FOAMED CONCRETE

1) The components of foam concrete mix should be set bytheir functional role in order as follows:
2) foaming agent
3) binding agent
4) water
5) aggregate
6) admixtures.

Making the Slurry

- The cement used for the slurry is usually Type 1 Portland Cement although other cements can be used. If sand is specified in the mix design ideally it should be fine with 2mm maximum size and 60 to 90% passing through a 600 micron sieve(8).
- The water:cement ratio of the slurry is usually between 0.5 and 0.6. If necessary more water can be added to increasedthe workability.
- The slurry can be made using a ready mix truck mixer.Firstly, the cement mortar slurry is made at the batching plant, according to the mix design, by either the

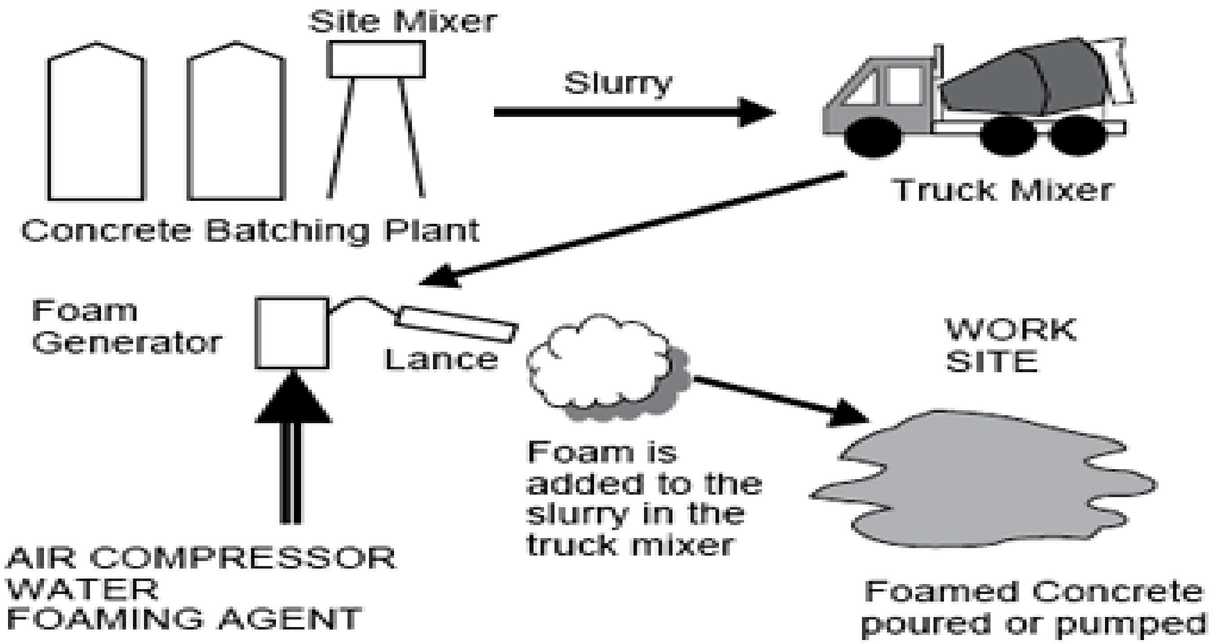
DRY orWET method.



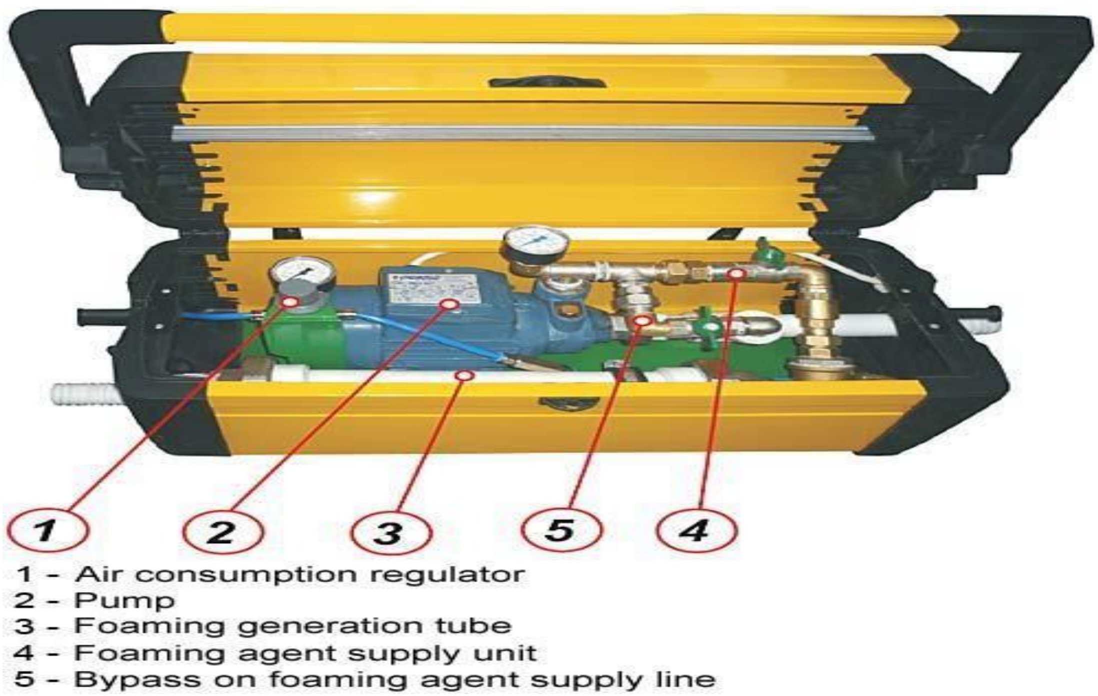
Making foam from foaming agent, water and compressed air.

- Foam for foamed concrete is made from a concentrated Foaming Agent. The foam is made using a foam generator.In the foam generator the foaming agent is diluted in water to make a prefoaming solution and then the pre- foaming solution is expanded with air into foam. The bubbles are stable and able to resist the physical and chemical forces imposed during mixing, placing and hardening of the foamed concrete. Between 75 and 85%of the bubbles are of 0.3 to 1.5 mm in diameter .

Making Foamed Concrete



A Schematic diagram showing the stages involvedwhen making foamed concrete.



- It is important to make the slurry first, before making the foam. Ideally the foam should be generated and delivered directly into the mixer of the ready mix truck that contains the slurry. The mixer should be rotated at approximately 10 revolutions per minute. All of the foam should be allowed to blend into the slurry.

Properties of foam concrete

1. Low heat transfer. Foamed concrete porous structure provides good insulation, so walls and floors made of foamed concrete do not need additional insulation.

2. Good acoustic insulation. Foamed concrete provides low noise transmission. This feature is necessary for making acoustical blanket on floor slabs made of structural concrete.

3. Ecological properties. Foamed concrete is one of the most eco-friendly and non-hazardous materials, also it doesn't educe any harmful substances in operation. It is inferior in environmental compatibility only to wood, but at the same time foamed concrete has longer lifetime and is more reliable.

4. Fire safety. Due to low heat transfer foamed concrete secures from fire and it is highly recommended for fire-resistant constructions.

5. Long time performance. Foamed concrete is resistant to moistness and doesn't decay.

6. Comfort operation conditions. In foamed concrete buildings thermal lost in cold seasons is minimized, and costs for conditioning in summer decrease.

Advantages of Foamed Concrete

1. Well bounded material.
2. Easily pumped over long distances for transporting and placing activity on site.
3. Self levelling material.
4. Resistant to fire.
5. Provides acoustic insulation.
6. Resistant to adverse effects of cold and warm climate.
7. Does not creates toxic substances hence eco-friendly material.
8. High strength with low density.
9. Resistant to adverse effects of seismic waves.
10. Cost saving.
11. Time saving hence rapid construction process.

Disadvantages of Foamed Concrete

1. Consumes more time for mixing process.
2. Due to absence of course aggregate, it shrinks more than normal concrete.
3. Flexural and compressive strength is low.

Applications of Foamed Concrete

1. Due to low density, it is used as filling material for cavities in slabs, concrete pits, etc..
2. Light weight foundation can be constructed.
3. Wall panels, floor, roofs can be constructed for thermal insulation.
4. Employing tilt up construction
5. Production of light weight blocks and precast panels.
6. Trench reinstatement.
7. Soil stabilization, Earthquake adverse effect resistances, Temperature change negative effects, floor heating systems are some of geotechnical applications.
8. It can be effectively used to fill voids of old sewers, water storage tanks, basement ducts.
9. Culvert filling, subway infill, tunnel grouting.

10. For road sub bases, foam concrete is also used for frost heave in roads, to fill voids in roadways due to heavy rains.
11. Acts as shock absorbing barriers for airport and regular traffic.
12. Prevention of frost heave in pile caps, shallow piles
13. Grout to fill abandoned pipes and as backfill under buried oil field modules to decrease temperature in hot oil tanks.
14. Fire insulation for any structure.

Mortar and Dry Pack

- Dry pack mortar, which is also called deck mud or floor mud, is a mixture of sand, cement, and water. It is used to repair small spots, creating thick bed mortar for tile and brick placement, and bed shower installation

- The proportion of the mixture is one part of cement to four part of sand, and adequate water to produce mortar that stick together when it is molded into a ball with hands as illustrated in Fig.1.

- Added to that, the ball shall not crumble as a result of low water and should not slump due to high-water proportion. This mixture is claimed to yield a compressive strength of 21 MPa.

Fig. 1: Adequate Amount of Water Added

Dry Pack Mortar - Applications and Advantages

Mixture Proportion

- It is reported that one part of cement to four part of sand, preferably sharp clean sand, is adequate. However, mix proportions like one to two and half, and one to five or even six are reported.

- With regard to quantity of water, it depends on the moisture content of used sand. if moisture of sand is low, greater quantity of water would be needed compare with case where moisture content is high.

Fig. 2: Dry Pack Mortar Before Adding Water

Applications of Dry Pack Mortar

1. Used to prepare ordinary thick mortar beds, as shown in Fig.4.
2. Employed to level concrete surfaces up to 51 mm thick
3. Used for floating shower bases, as illustrated in Fig.5.
4. It can be directly bonded or used as a detached floating mortar bed over a cleavage membrane or waterproofing membrane
5. Use in both residential and commercial applications in dry and wet areas
6. Dry pack mortar is used to fill deep holes in a concrete wall. As the dry pack mortar components are mixed, it should be placed in layers of 10mm and then compacted with hammer, stick, or hardwood dowel. It is recommended to employ metal stick to compact dry pack mortar rather than wooden stick. This is because metal stick yields better compaction and ensure greater bond. Additionally, it is advised to apply direct tamping at an angle to the sides of the hole to ensure good compaction at the sides of the hole.

Fig. 4: Setting Bed for Installation of Bricks

Advantages of Dry Pack Mortar

1. Used for Interior and Exterior applications
2. Jobsite mixing of sand and cement is no longer needed
3. It can be tamped, compacted, and sloped easily
4. It guarantees a consistent mix on large jobs

Vacuum concrete

What is Vacuum Concrete?

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..

Technique and Equipments for Vacuum Concrete:

The main aim of the technique is to extract extra water from concrete surface using **vacuum dewatering**. As a result of dewatering, there is a marked reduction in effective water-cement ratio and the performance of concrete improves drastically. The improvement is more on the surface where it is required the most. Mainly, **four components are required in vacuum dewatering of concrete**, which are given below:

1. Vacuum pump
2. Water separator
3. Filtering pad
4. Screed board vibrator

Procedure

In the usual manner, a concrete mix with good workability is pace in the form-works. As fresh concrete contains continues the system of water-filled channels, the application of a vacuum to the surface concrete results in a large amount of a vacuum to the surface of the concrete. This results in a large amount of water being extracted from a certain depth of the concrete. The vacuum is applied through porous mats connected to a vacuum pump. The final water cement ratio before setting is thus reduced and as this ration largely controls the strength, vacuum concrete has a higher strength and also density a lower permeability and a greater durability.

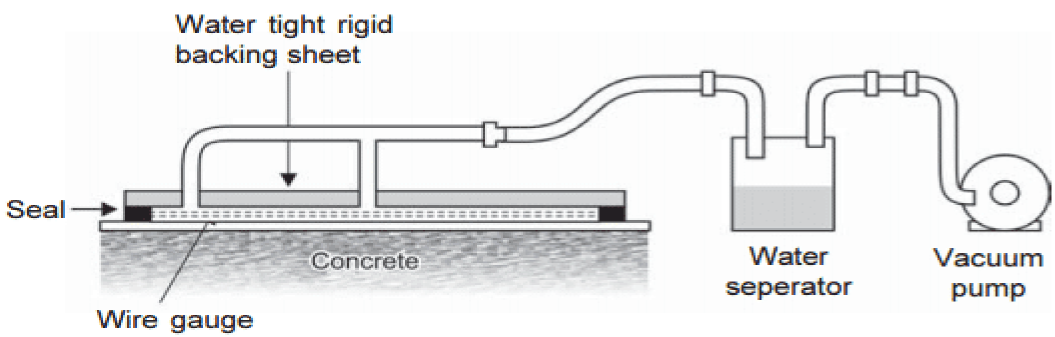


Fig. 1: Vacuum dewatering of concrete

Advantages of vacuum concreting:

- Due to dewatering through vacuum, both workability and high strength are achieved simultaneously.

- Reduction in water-cement ratio may increase the compressive strength by 10 to 50% and lowers the permeability.
- It enhances the wear resistance of concrete surface.
- The surface obtained after vacuum dewatering is plain and smooth due to reduced shrinkage.
- The formwork can be removed early and surface can be put to use early.

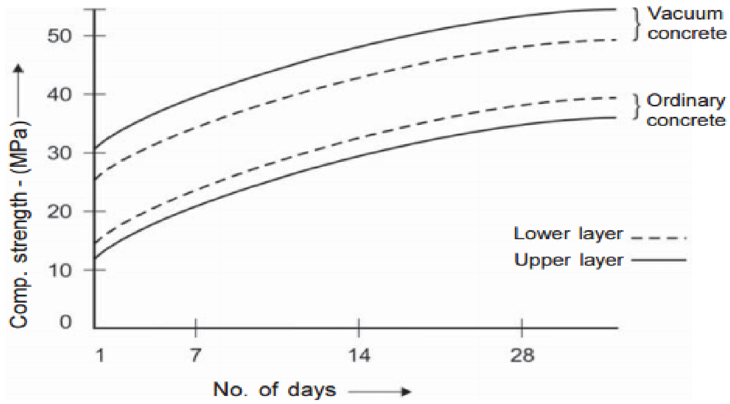


Fig. 2: Effect of vacuum dewatering of concrete

The advantages of dewatering are more prominent on the top layer as compared to bottom layer as shown in fig. 2 above. The effect beyond a depth of 150mm is negligible.

Gunite and Shotcrete

What Is Shotcrete?

Shotcrete is similar to gunite, which is also made of cement, sand, water. The prepared mixture is sprayed on the surface just like guniting.

In guniting, water is added to the material to form concrete onsite. While in shotcrete, a “wet mix” is prepared by mixing the water and dry mix before arrival. This pre-mixed cement is shot out or sprayed of a nozzle to form the pool.

In shotcrete, the water-cement ratio usually ranges from 35 to 0.50 by mass which is somewhat lower than most conventional concrete mixes. Shotcrete can be used as both wet mix and dry mix.

Advantage Of Shotcrete

The various advantages of the shotcrete process are as follows.

- The shotcrete process forms a uniform and strong layer of concrete on the surface.
- Like the guniting process, the shotcrete process is more economical than conventional concrete, which requires wooden or steel formwork.
- Shotcreting can be used in construction where the formwork cannot be installed.
- The concrete can be applied to one nozzle from a safe distance.
- The required materials in this process can be accessible in most places.
- Specialized admixtures can be added to the concrete to achieve more efficiency
- As it is pre-mixed, there is no additional need for water while applying.
- Shotcrete helps to achieve high production rates.
- No Need for skilled workers. As it is a pre-mixed mixture.
- In terms of pressure application, shotcrete is faster than guniting.
- Material requirements are fewer.

Disadvantages Of Shotcrete

- If the hose gets blocked, It will be very tough to clear it, which could be dangerous for the crew and property.
- Though it does not need any additional water during its application, some water is required for pumping.
- The hoses are very heavy, which would be more challenging to use for the crew
- Like guniting, You can’t start and stop the application. Doing so may create weak points in the concrete.
- The application process is quick. As the mixture is pre-mixed.
- Chances of developing cracks are more if the excess water is added to the pre-mixed concrete.
- This process is not so economical when compared to guniting.

Applications Of Shotcrete

- Dome construction
- Retention walls
- Tunneling
- Artificial Ponds
- Mining Applications
- Dikes and Dams

- Ditches and Channels
- Water tanks and Ponds
- Slope Stabilization

What Is Gunite?

Gunite is a mixture made of cement, sand, and water. Gunite is similar to concrete, but the traditional pouring method is not adopted here; instead sprayed with a gun in several layers. Hence it is named gunite.

While preparing the mixture, water is added to the dry concrete mix at the gun-shaped nozzle opening. Generally, concrete is made in the air just before hitting the target.

As per pool professionals, gunite is a “dry mix” because the water is added to the material to form concrete onsite, and it is also known as Dry shotcrete.

Advantages of Guniting

The advantages of guniting are as follows:

- Guniting is highly durable and gives the flexibility to create structure in any shape.
- Gunite gives a more variety of finishes. Plaster finishes come in an array of shades from which we can choose according to the outdoor living area and house design.
- The preparation process of dry mix is speedy compared to wet shotcrete mix.
- The guniting process helps to achieve a high compressive strength of concrete.
- The guniting process is mostly used in artificial caves and swimming pools to create unique shapes and features.
- Gunite also makes it easy to design and build features like waterfalls and customs steps.
- The guniting process is less expensive than shotcrete.

Disadvantages Of Guniting

The various disadvantages of the Guniting process are as follows.

- During the application of dry mix concrete, the Chance of clogging or blockage of a hosepipe is more.
- Skilled workers are needed for the guniting process.
- Skill workers are directly proportional to the quality of work. That means the quality of the job depends upon the operator.
- In the guniting process, there may be chances of wastage of concrete.

Applications Of Guniting

- Dome construction
- Tunneling
- Artificial Ponds
- Mining Applications
- Dikes and Dams
- Ditches and Channels
- Water tanks and Ponds
- Slope Stabilization

Lets check the differences in detail.

Difference Between Shotcrete And Gunite

Shotcrete Vs Gunite

Sl. No	Gunite	Shotcrete
1	The guniting process is economical	While shotcrete is a bit more expensive.
2	The guniting process involves only dry mix, hence it is also called dry shotcrete.	The Shotcrete process involves both dry mixes as well as wet mixes.
3	The guniting process is most suitable for small works.	The shotcrete process is most suitable for large works.
4	The guniting process requires skilled workmanship.	The shotcrete process requires less skilled workmanship.
5	The waste generated while applying in guniting is more.	The waste generated while applying shotcrete is less.
6	The guniting process requires more time duration.	The shotcrete process requires less time duration.
7	There are no shrinkage cracks in guniting.	High chances of shrinkage cracks in shotcrete.
8	Higher compressive strength (from 7,000 to 9,500psi)	Less compressive strength (6,500 to 7,500psi)
9	Guniting has low production rates.	Shotcrete has high production rates.
10	The process can be halted in between and can be continued without any problem.	In shotcrete the application process must not be halted, doing so may result in weak points in concrete.

Process of Gunite

There are two different processes in use, namely the "Wet-mix" process and the "dry-mix" process. The dry mix process is more successful and generally used.

Dry-mix Process

- The dry mix process consists of number of stages and calls for some specialized plan. A typical small plant set-up is shown.
- 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.
- The wet mortar is jetted from the nozzle at high velocity onto the surface to gunited.

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 a compressed air, onto the work in the same way, as that of dry-mix process.
- The wet-mix process has been generally discarded in favour of dry-mix process, owing to the greater success of the latter.
- The dry-mix method makes use of high velocity or low velocity system fully. The high velocity gunite is produced by using the small nozzle and a high air pressure to produce a high nozzle velocity of about 90 to 120 meters/sec.
- This results in exceptional good compaction. The lower velocity gunite is produced using large diameter hose for large output. The compaction will not be very high.

Epoxy Injection

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 toseal the crack at surface between the holes with rapid curing resin.

For repairs of cracks in massive structures, a series of holes (Usually 20mm 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 thecracks are actively leaking and cannot be dried out.

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

i. **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.

ii. **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 20mm dia and 12 to25mm below the apex of V-grooved section, is drilled into the crack. A tire-calue stren isbonded with an epoxy adhesive in the hole. In case the cracks are not V-grooved, the entry port is provided by bonding a fitting, having a hat-like croos-section with an opening at the top for adhesive to enter, flush with the concrete face over the crack.

iii. **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.

iv. **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 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 seldom 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 millimeters may be enough.

v. **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.

1 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 surface-dried 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.

2Curing

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.

3 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.

Shoring & Underpinning

What is shoring?

Shoring is a general term used in construction to describe the process of supporting a structure in order to prevent collapse so that construction can proceed. The phrase can also be used as a noun to refer to the materials used in the process.

Uses of Shoring in Building Construction

Shoring is used to support the beams and floors in a building while a column or wall is removed. In this situation vertical supports are used as a temporary replacement for the building columns or walls. Trenches - During excavation, shoring systems provide safety for workers in a trench and speed excavation. In this case, shoring should not be confused with shielding. Shoring is designed to prevent collapse where shielding is only designed to protect workers when collapses occur. concrete structures shoring, in this case also referred to as falsework, provides temporary support until the concrete becomes hard and achieves the desired strength to support loads.

Shoring Techniques in Building Construction

Raking Shore
Raking Shores consist of one or more timbers sloping between the face of the structure to be supported and the ground. The most effective support is given if the raker meets the wall at an angle of 60 to 70 degrees. A wall-plate is typically used to increase the area of support.

Hydraulic Shoring
Hydraulic shoring is the use of hydraulic pistons that can be pumped outward until they press up against the trench walls. They are typically combined with steel plate or plywood, either being 1-1/8" thick plywood, or special heavy Finland Form (FINFORM) 7/8" thick.

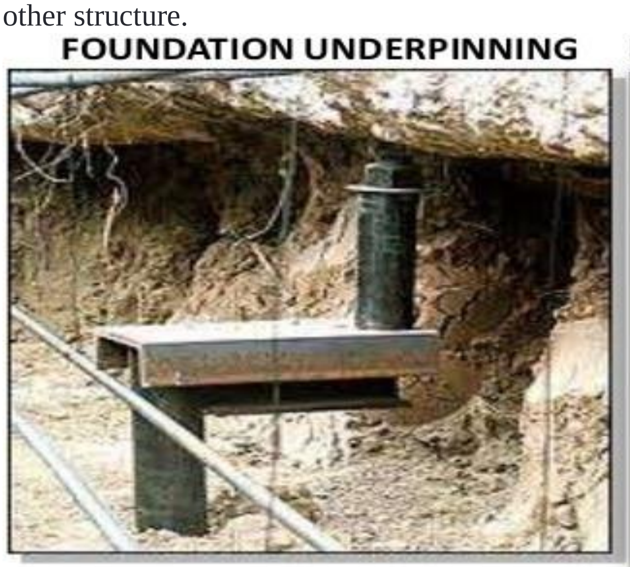
Beam and Plate
Beam and Plate steel I-beams are driven into the ground and steel plates are slid in amongst them. A similar method that uses wood planks is called soldier boarding. Hydraulics tend to be faster and easier; the other methods tend to be used for longer term applications or larger excavations.

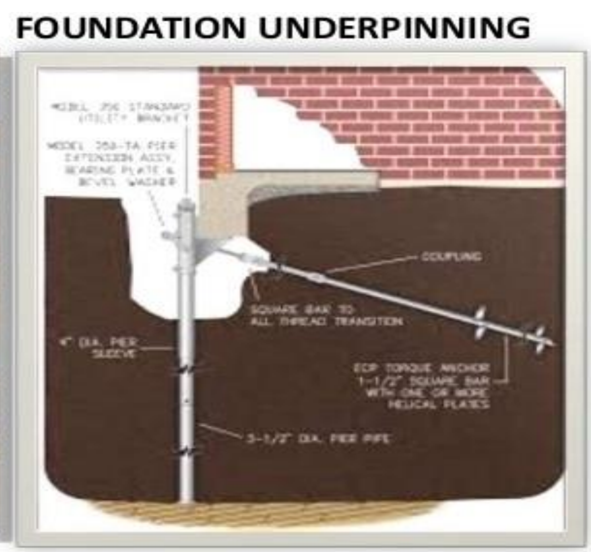
Soil Nailing
Soil nailing is a technique in which soil slopes, excavations or retaining walls are reinforced by the insertion of relatively slender elements - normally steel reinforcing bars. The bars are usually installed into a pre-drilled hole and then grouted into place or drilled and grouted simultaneously. They are usually installed untensioned at a slight downward inclination. A rigid or flexible facing (often sprayed concrete) or isolated soil nail heads may be used at the surface.

Continuous Flight Augering
Continuous Flight Augering (CFA) is a method used to create concrete piles to support soil so that excavation can take place nearby. A Continuous Flight Augering drill is used to excavate a hole and concrete is injected through a hollow shaft under pressure as the auger is extracted. This creates a continuous pile without ever leaving an open hole.

What is underpinning?

Underpinning is the process of strengthening and stabilizing the foundation of an existing building or other structure.





Underpinning in Building Construction

Underpinning may be necessary for a variety of reasons:

- The original foundation is simply not strong or stable enough, e.g. due to decay of wooden piles under the foundation.

- The usage of the structure has changed.
- The properties of the soil supporting the foundation may have changed (possibly through subsidence) or were mischaracterized during planning.
- The construction of nearby structures necessitates the excavation of soil supporting existing foundations.
- It is more economical, due to land price or otherwise, to work on the present structure's foundation than to build a new one.

Underpinning is accomplished by extending the foundation in depth or in breadth so it either rests on a stronger soil stratum or distributes its load across a greater area. Use of micropiles and jet grouting are common methods in underpinning. An alternative to underpinning is the strengthening of the soil by the introduction of a grout. All of these processes are generally expensive and elaborate.

Corrosion Mechanism

What is corrosion?

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.

So in other words for corrosion to occur four basic elements are required:

- Anode – Site where corrosion occurs and current flows from
- Cathode – Site where no corrosion occurs and current flows to.
- Electrolyte – A medium capable of conducting electric current by ionic current flow (i.e Soil, Water or Concrete)

. • Metallic path – connection between the anode and cathode, which allows current returnand completes the circuit.

Reinforcing steel in concrete normally does not corrode because of the formation of a passive oxide film on the surface of the steel due to the initial corrosion reaction.

The process of hydration of cement in freshly placed concrete develops a high alkalinity, which in the presence of oxygen stabilizes the film on the surface of embedded steel, ensuring continued protection while the alkalinity is retained.

Normally, concrete exhibits a pH above 12 because of the presence of calcium hydroxide, potassium hydroxide – the term pH is a measure of the alkalinity or acidity, ranging from highly alkaline at 14 to highly acidic at zero, with neutrality at 7. Although the precise nature of this passive film is unknown, it isolates the steel from the environment and slows further corrosion aslong as the film is intact.

There are two major situations in which corrosion ofreinforcing 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.

$Ca(OH)_2 + CO_2 \square CaCo3 + H_2O$

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.

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. Problemsare 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 Chloride

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.

As concrete has a low tensile strength it will crack when as little as a tenth of a millimeter 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:

- Pre-stressed concrete 0.08%
- Reinforced concrete in wet conditions 0.10%
- Reinforced concrete in dry conditions 0.20%
- But in existing structures 0.026% is enough to breakdown the Passive Layer.

Factors Influencing corrosion of Reinforcement

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

- General Influencing factors
- General accelerating factors

General Influencing factors

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

1. pH Value
2. Moisture
3. Oxygen
4. Carbonation
5. Chlorides
6. Ambient temperature Severity of exposure Quality of concrete
7. Cover to the reinforcement Initial curing condition
8. Formation of cracks

General Accelerating factors

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

- Chlorides
- Sulphates
- Chlorine
- Electrical Charges
- Methane Acids

4.8.2.1 Methods of Corrosion Protection

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

- Protective coatings for reinforcement

- Cathodic protection
- Corrosion Resistant steel
- Corrosion 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:

i. Cement Slurry Coating

- Cement Slurry Coating provides short-term protection until placement inconcrete.
- Several methods have been developed for an effective corrosion protectionusing cement slurry.
- One such coating is a mixture of cement, condensed silica and polymerdispersion.
- This mixer found to be impermeable to water, chlorides and carbon-di-oxide.

ii. Epoxy Coating

- Epoxy coating is formed by application of an epoxy resin with appropriatecuring 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 effectivein high alkaline and chloride contaminated environment.

iii. Plastic Coating

- Similar to epoxy coating, the plastic coatings are very effective in preventing corrosion of reinforcement even in high alkaline or chloridecontaminated 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 besolved by conventional methods.

iv. 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 ofgalvanizing protection is reduce and hence is not advisable in highly chloride contaminated environments.

Cathodic protection

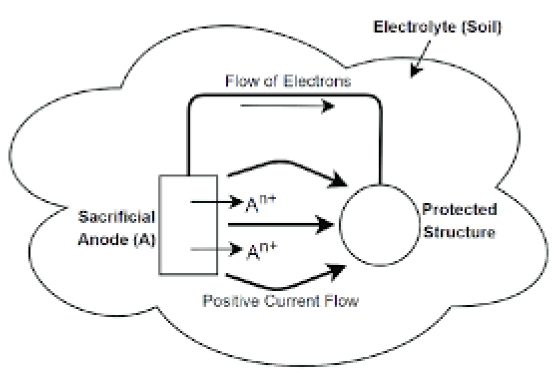
- Cathodic protection interferes with the natural action of theelectrochemical cells that are responsible for corrosion.
- Cathodic protection can be effectively applied to control corrosion ofsurfaces that are immersed in water or exposed to soil.
- Cathodic protection in its classical form cannot be used to protect surfacesexposed 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.

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

They are

1. Cathodic protection with galvanic anodes.
2. Impressed current cathodic protection

1. Cathodic protection with galvanic anodes



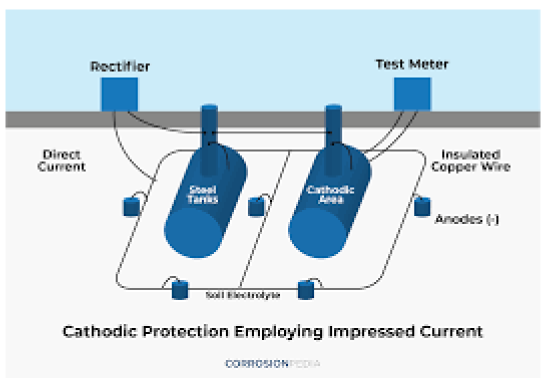
- **Cathodic protection (CP)** is a technique to control the corrosion of a metal surface by making it work as a cathode of an electrochemical cell. This is achievedby placing in contact with the metal to be protected another more easily corroded metal to act as the anode of the electrochemical cell.

- 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.

2. Impressed current Cathodic protection



In impressed current cathodic protection, an alternative source of direct electrical current, usually a rectifier that converts alternating current to direct current is used to provide therequired electrical current. In this system, the electrical circuit is completed through an inert anode material that is not consumed in the process.

As shown in Figure low energy electrons that are picked up at a non-reactive anode bed are given additional energy by the action of a rectifier to be more energetic than the electrons that would be produced in the corrosion reaction.

The energy for the "electron energy pump" action of the rectifier is provided by ordinary alternating current. The effect of these electrons at the structure being protected is the same as that derived from the sacrificial anode type of cathodic protection system. However, the anode materials (such as magnetic, platinum, and newly developed ceramic materials) have beensuccessfully used.

For buried anodes, a backfill of carbonaceous material is used to surround the anode to decrease the electrical resistance of the anode, to provide a uniform, low resistivity environment surrounding the anode and to allow gasses produced at the anode surface to vent. In practice, materials such as graphite are used for impressed current cathodic protection system anodes that are slowly consumed. Anodes in impressed current systems must be inspected and replaced if consumed or otherwise damaged.

Engineered demolition techniques for dilapidated structures

Preliminary investigation

Demolition is a highly skilled and dangerous activity in terms of damage to life and property and there are certain basic factors to consider before a contract is placed:

- The demolition contractor should have ample experience of the type of work to beoffered;
- Fully comprehensive insurance against all risks must be maintained at all times; An experienced supervisor should be continuously in charge of the work;
- The contract price should include all safety precautions included in the relevant buildingregulations;
- The completion date should be realistic, avoiding and need to take risks to achieve thedate.

Preliminary Considerations

Demolition operations are the subject of strict legal control – there is a substantial body of legislation and a great deal of case law relating to such operations. There may also be some regulations which impose additional restrictions: for example, action against nuisance such as noise and dust.

The BSI Code of Practice for Demolition BS 6187 exerts further influence, in that if the Demolition contractor does not observe the recommendation of the Code, this may well influence a Court‟s decision as to his liability in any legal proceedings.

General Site Provisions

A. Plant and Equipment: Must only be operated by skilled operators and must be regularly serviced.

B. Protective Clothing: Buildings where chemicals have been stored or where asbestos, lead paint, dust or fumes may be present will require specialized protective clothing, e.g. Respirators, helmets, goggles, footwear, gloves, etc. Projecting nails, pieces of metal, etc. resulting from demolition can cause accidents.

C. Shoring and Underpinning: The demolition contractor has a legal obligation to show technical competence when carrying out the work. When removing sections of the building which could have leave other parts unsafe, adequate temporary supports and shoring etc. must be provided.

D. Working Areas: These will need to be well signposted and clear warnings given that demolition work is in progress. This may include the necessity for some kind of lighting.

E. Debris: Sections of the building must not be overloaded with debris either on suspended floors or against party walls.

F. Weather Conditions: These can affect safety. Strong winds or drifting snow against unsafe walls. Suspended floors etc. which are unpropped may lead to collapse.

G. Flooding: The build-up of water can sometimes be hazardous.

H. Overhead Cables: A crane heights etc. must be checked against the height of any surrounding overhead cables to avoid damage and cutting off supplies etc.

I. Scaffolding and Hoarding: These must be constructed and illuminated to the relevant building regulations.

J. Security: The demolition site and any partially demolished buildings must be properly secured against entry.

K. Dust: Should be kept to a minimum by spraying with water when necessary.

L. Noise: Suppressors and silencers, particularly on compressors etc., should be used to keep noise levels to a minimum.

Demolition Methods for Buildings and other structures

There are two types of demolition methods used for buildings and structures

1. Non-explosive demolition
2. Explosive demolition.

1. Non-Explosive Demolition Method

It means the demolition of a structure done with some equipment without the use of any explosive. Different equipment's used for the demolition activity are

a) Sledge hammer

It is a small handheld hammer used for the demolition of small wall or single column.

b) Excavators and Bulldozers

These are big machines uses to demolish building of small sizes. They are used for excavation of soil or transferring of debris to trucks etc.

c) Wrecking Balls

The building with the greater height up to (6-7 story) cannot be demolished with the help of excavators or bulldozers. In such cases crane with wrecking balls are used to perform the demolition activity. The wrecking ball crack is crack attached with a huge steel ball hanging from a steel rope. The steel ball is pulled and released towards the building. The steel ball with force strikes the building and the part of the building is demolished. This method is not recommended as the trajectory of the steel ball cannot be controlled after it strikes the structure.

d) High Reach Excavators

High Reach Excavator machines are used in the demolition of tall building where demolition by explosion is not possible. The building of height up to 300ft can be demolished by this type of machine. High reach excavators can be used for different use by doing some attachments such as:

- Excavators with shear attachments - excavators with shear attachments.
- Hydraulic hammers - Hydraulic hammers and remove steel reinforcement.

Explosive Demolition Method for Building Structures

Implosion Method of Building Demolition

Implosion is the process of demolition of a building using explosives. If the supports of the building are removed, the structure collapses. Using implosion technique, the main supports of the buildings such as column's, beams and slab are fixed with explosives. When these explosives are detonated, the column collapse and so is the structure. Depending how the structure falls, there are two types of implosion:

a) Falling like a tree

In this type of implosion, the building is made to fall like a tree to the sideward. This is the commonly used type of implosion. When free space is available besides the building, this type of demolition is prescribed. If the free space is available on the left side of the building, the explosives are set on the lower level of the building on the left side columns. As the explosives are detonated, the columns bursts, the building tends to falls towards the left side. Steel cables are tied to the building to control the falling direction of the building.

b) Falling into its own footprint

When the free spaces are not available around the building and the structure around the building are to be protected. This type of demolition is used. In this type of demolition, explosives are set in the floor below the middle part of the building.

These explosives are to be heavy as the explosion must demolish the building at once. If one part blast and followed by another. Then the building falls towards the first blasted part. So only less companies in the world are experienced in this type of demolition. As the explosions are detonated, the upper part of building destroys and falls upon the lower building. Due to the heavy load and force the lower part of the building also collapses and falls on its own footprint.