Source:theconstructor.org.

UNIT-V: Repair, Rehabilitation and Retrofitting of structures

Repair:

Repair is the process of restoring something that is damaged or deteriorated or broken, to good condition.

- The main purpose of repairs is to bring back the architectural shape of the building so that all services start working and the functioning of building is resumed quickly.
- Repair does not pretend to improve the structural strength of the building and can be very deceptive for meeting the strength requirements of the next earthquake.

The actions will include the following:

(i) Patching up of defects such as cracks and fall of plaster.

(ii) Repairing doors, windows, replacement of glass panes.

(iii) Checking and repairing electric wiring.

(iv) Checking and repairing gas pipes, water pipes and plumbing services.

(v) Re-building non-structural walls, smoke chimneys, boundary walls, etc.

(vi) Re-plastering of walls as required.

vii) Rearranging disturbed roofing tiles.

(viii) Relaying cracked flooring at ground level.

(ix) Redecoration. whitewashing, painting, etc

Rehabilitation/ Restoration:-

Rehabilitation is the process of returning a building or an area to its previous good conditions. It is the restitution of the strength the building had before the damage occurred.

- The main purpose of restoration is to carry out structural repairs to load bearing elements.
- It may involve cutting portions of the elements and rebuilding them or simply adding more structural material so that the original strength is restored.
- The process may involve inserting temporary supports, underpinning, etc

The actions will include the following.

(i) Removal of portions of cracked masonry walls and piers and rebuilding them in richer mortar. Use of non shrinking mortar will be preferable.

(ii) Addition of reinforcing mesh on both -faces of the cracked wall, holding it to the wall through spikes or bolts and then covering it suitably.

(iii) Injecting epoxy like material, which is strong in tension, into the cracks in walls, columns, beams, etc.

1. Underpinning Methods in Foundation Strengthening:

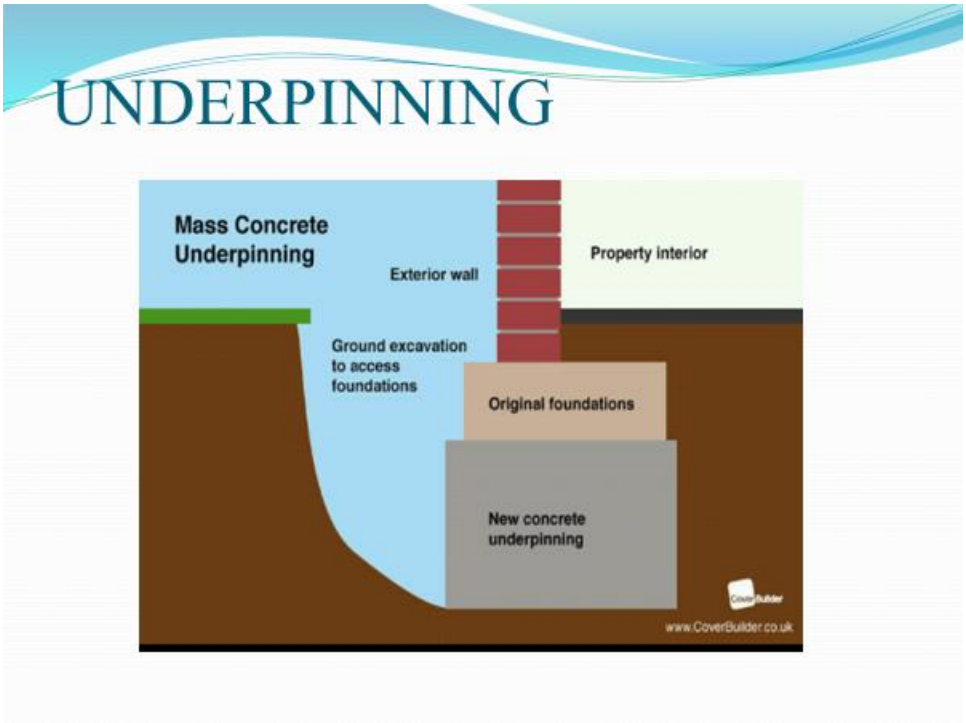
Underpinning is a method for repair and strengthening of building foundations. Underpinning methods, procedures and their applications in strengthening of different types of foundations is discussed here.

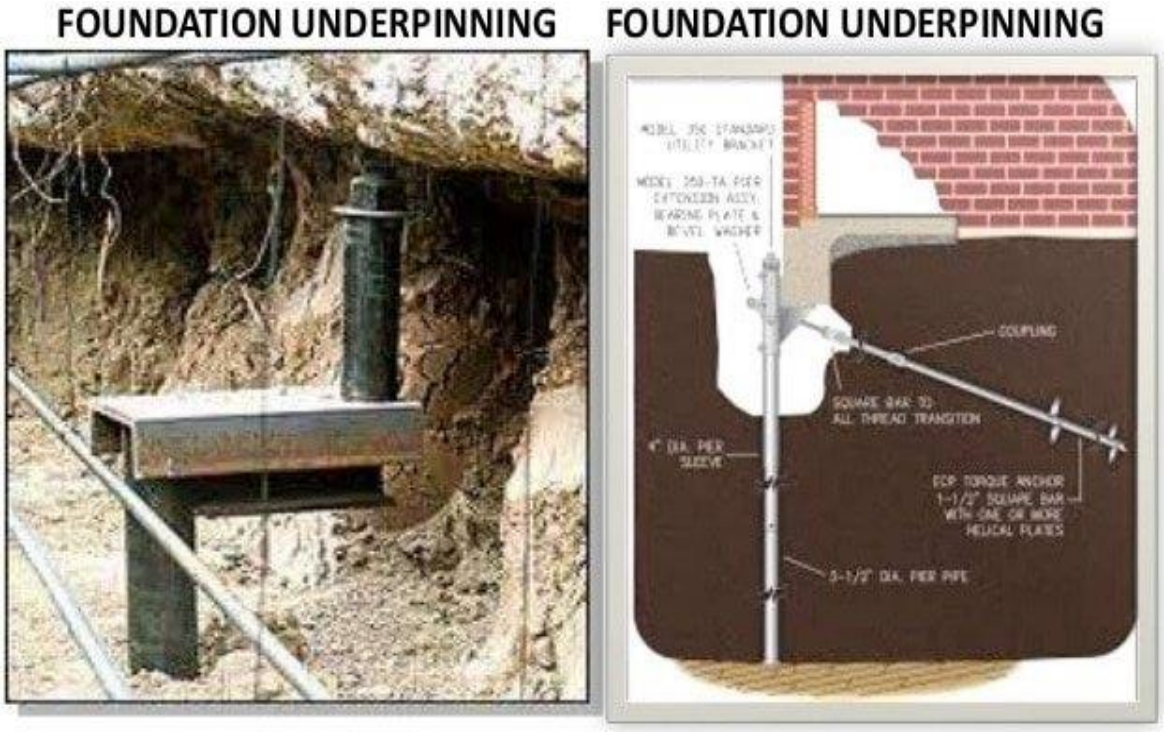
Underpinning is the process of strengthening and stabilizing the foundation of an existing building or other structure.

There are situations where a failure in foundation or footing happens unexpectedly after the completion of whole structure (both sub and superstructure). Under such an emergency situation, a remedial method has to be suggested to regain the structural stability.

The **method of underpinning** help to strengthen the foundation of an existing building or any other infrastructure. These involve installation of permanent or temporary support to an already held foundation so that additional depth and bearing capacity is achieved.

This is the best solution whereby the footings of the building are underpinned with either concrete, masonry or piles to carry the load of the building down to a more stable stratum .This solution is usually the most costly, particularly if there are access difficulties or if internal walls require underpinning, which may require lifting internal floors.





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.

Fig.1: Underpinning Method; Image Courtesy: Moretrench -Hayward Baker Company

Selection of Underpinning Methods:

Underpinning methods are selected based on age of structure and types of works involved.

Structure categories based on its age:

- Ancient Structures :Age greater than 150 years
- Recent Structures : Age between 50 – 150 years
- Modern Structure : Age less than 50 years

Types of works for selection of underpinning methods:

Conversion Works

The structure has to be converted to another function, which requires stronger foundation compared to existing

Protection Works:

The following problems of a building has to undergo protection works:

- The existing foundation is not strong or stable
- Nearby excavation would affect the soil that supports existing footing.
- Stabilization of the foundation soil to resist against natural calamities
- Requirement of basement below an already existing structure

Remedial Works:

- Mistakes in initial foundation design caused subsidence of the structure
- Work on present structure than building a new one

Structural Conditions which Requires Underpinning:

There are many reasons that make an engineer to suggest underpinning method for stabilization of the substructure such as:

- The degradation of timber piles used as a foundation for normal buildings would cause settlement. This degradation of structures is due to water table fluctuations.
- Rise and lowering of the water table can cause a decrease of bearing capacity of soil making the structure to settle.
- Structures that are built over soil with a bearing capacity not suitable for the structure would cause settlement.

Need for Underpinning

The decision of underpinning requirement can be made based on observations. When an already existing structures start to show certain change through settlement or any kind of distress, it is necessary to establish vertical level readings as well as at the offset level, on a timely basis. The time period depends upon the how severe is the settlement.

Now, before the excavation for a new project, professionals have to closely examine and determine the soil capability to resist the structure that is coming over it. Based on that report the need for underpinning is decided. Sometimes such test would avoid underpinning to be done after the whole structure is constructed.

Methods of Underpinning

Following are the different underpinning methods used for foundation strengthening:

- **Mass concrete underpinning method (pit method)**
- **Underpinning by cantilever needle beam method**
- Pier and beam underpinning method
- Mini piled underpinning
- Pile method of underpinning
- Pre-test method of underpinning

Whatever be the types of underpinning method selected for strengthening the foundation, all of them follow a similar idea of extending the existing foundation either lengthwise or breadthwise and to be laid over a stronger soil stratum. This enables distribution of load over a greater area.

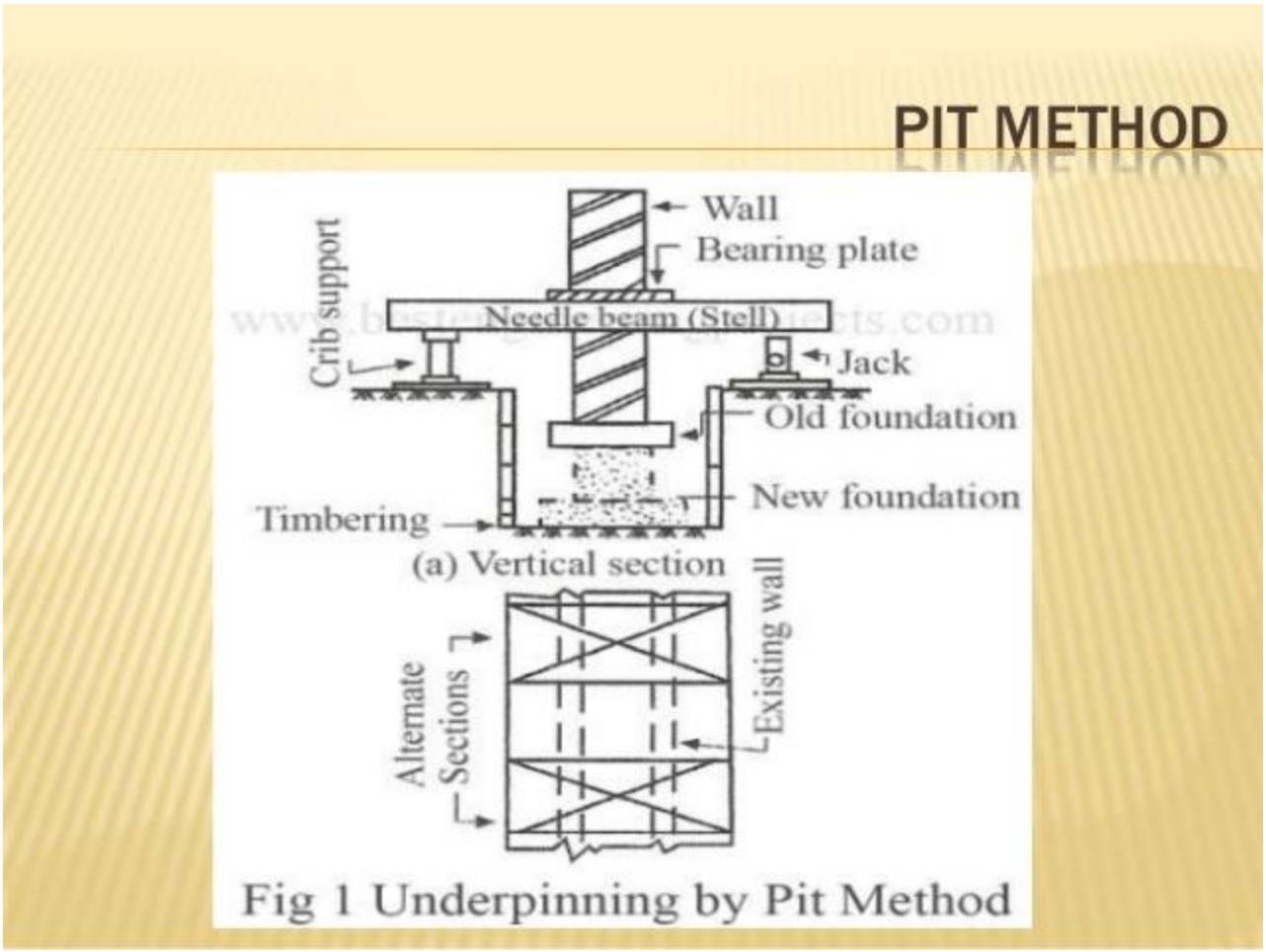
Different underpinning methods are mentioned briefly in the following sections. The choice of method depends on the ground conditions and the required foundation depth.

1. Mass Concrete Underpinning Method (Pit Method)

Mass concrete underpinning method is the traditional method of underpinning, as it has been followed by centuries. The method involves extending the old foundation till it reaches a stable stratum.

The soil below the existing foundation is excavated in a controlled manner through stages or pins. When strata suitable is reached, the excavation is filled with concrete and kept for curing, before next excavation starts.

In order to transfer the load from old foundation to new one, a new pin is provided by means of placing dry sand-cement pack. This is a low-cost method suitable for the shallow foundation.



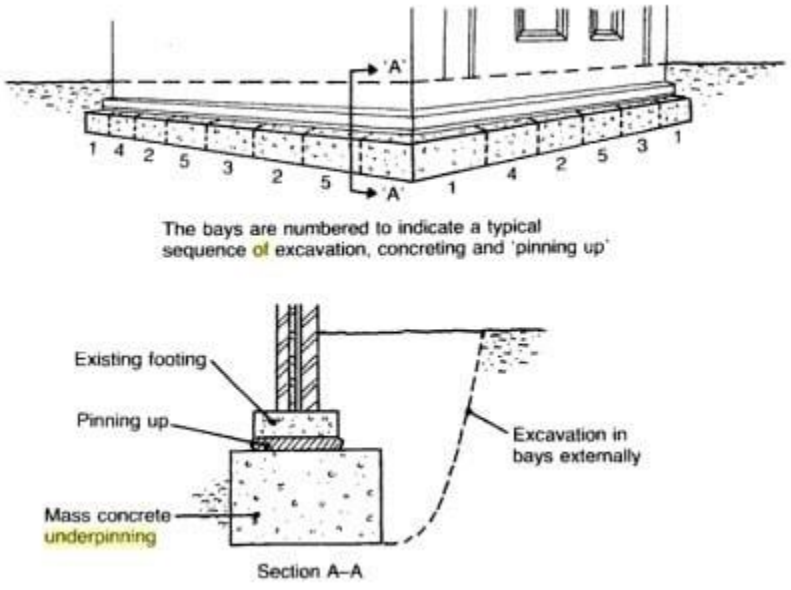


Fig.1: Mass Concrete Underpinning

For more complicated problems related to the foundation other superior methods have to chosen.

2. Underpinning By Cantilever Needle Beam Method

Figure-2 represents the arrangement of cantilever pit method of underpinning, which is an extension of pit method. If the foundation has to be extended only to one side and the plan possess a stronger interior column, this method can be used for underpinning.

Advantages of Cantilever Needle Beam Method:

- Faster than traditional method
- One side access only
- High load carrying capability

Disadvantages:

- Digging found uneconomical when existing foundation is deep
- Constraint in access restricts the use of needle beams

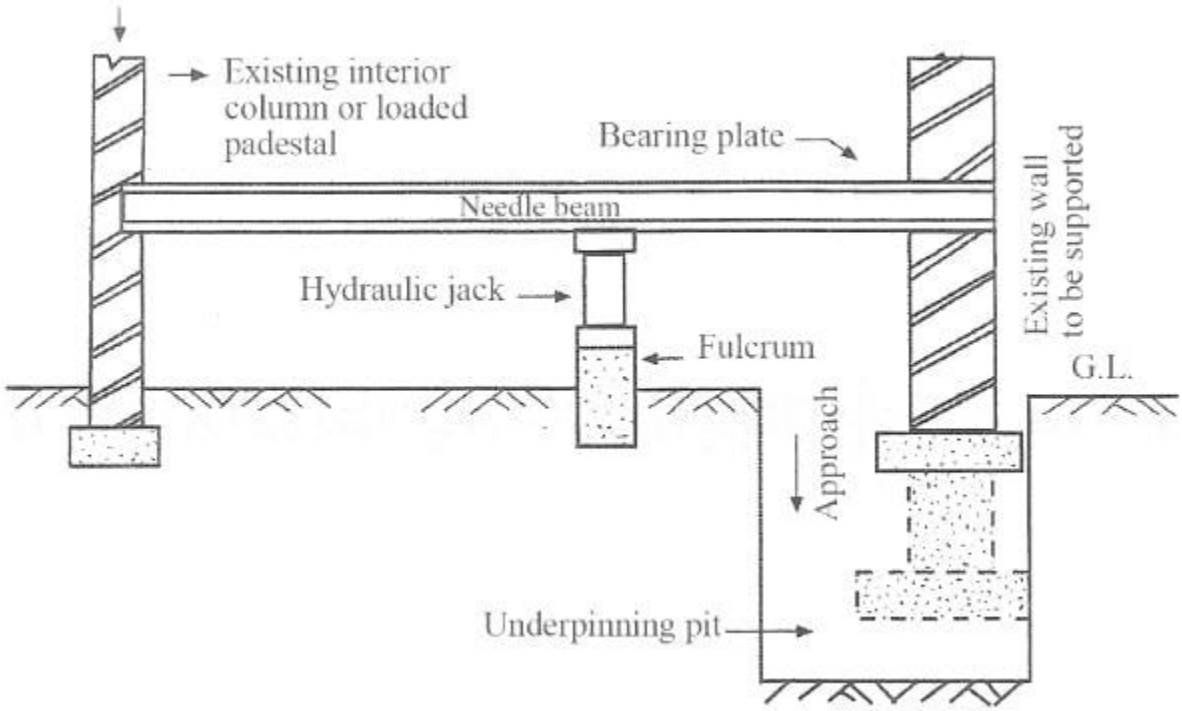


Fig.2: Cantilever Needle Beam Underpinning Method

3. Pier and Beam Underpinning Method

It is also termed as base and beam method which was implemented after the second world war. This method progressed because the mass concrete method couldn't work well for a huge depth of foundation.

It is found feasible for most of the ground conditions. Here reinforced concrete beams are placed to transfer the load to mass concrete bases or piers as shown in figure 2.

The size and depth of the beams are based on the ground conditions and applied loads. It is found economical for depth shallower than 6m.

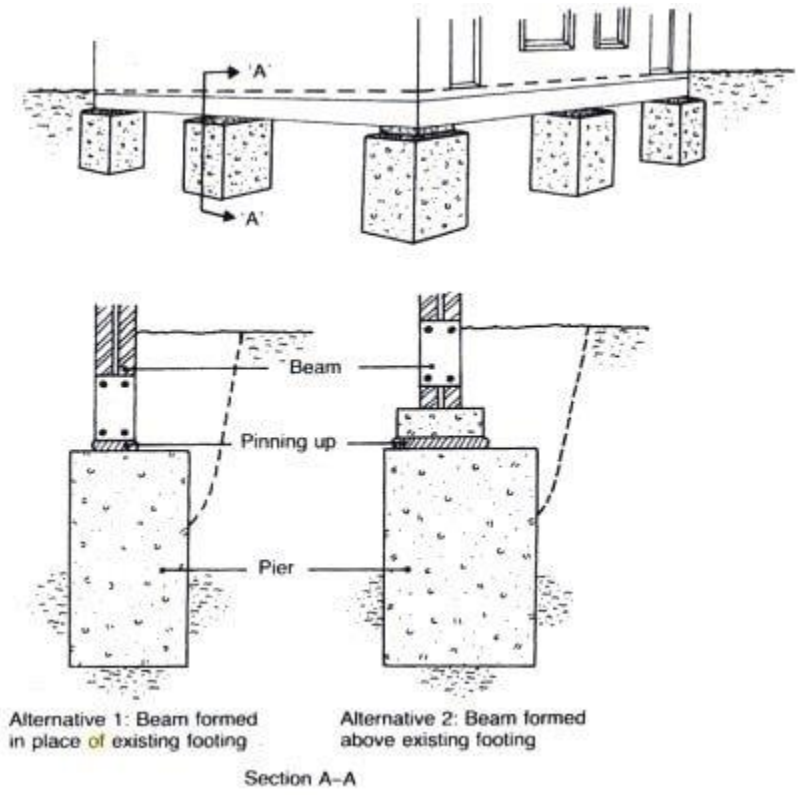


Fig.3: Pier and Beam Underpinning Method

4. Mini Piled Underpinning

This method can be implemented where the loads from the foundation have to transferred to strata located at a distance greater than 5m. This method is adaptable for soil that has variable nature, access is restrictive and causes environmental pollution problems.

Piles of diameter between 150 to 300mm in diameter is driven which may be either augured or driven steel cased ones.

5. Pile Method of Underpinning

In this method, piles are driven on adjacent sides of the wall that supports the weak foundation. A needle or pin penetrates through the wall that is in turn connected to the piles as shown in figure-4.

These needles behave like pile caps. Settlement in soil due to water clogging or clayey nature can be treated by this method

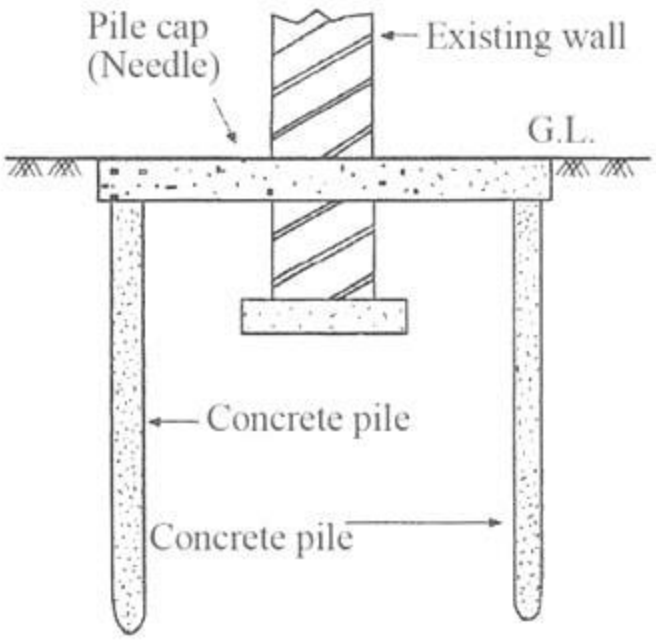


Fig.4: Underpinning by Pile Method

6. Pre-test Method of Underpinning

It is employed for strip or pad foundation. Can be used for building with 5 to 10 stories. Here the subsoil is made compact and compressed, in the new excavation level that gives predetermined loads to the soil. This is done before underpinning is performed.

Note: read and understand the methods as per curriculum (method 1 and 2)

2. Retrofitting of RCC Structural Members:

Retrofitting of RCC structural members is carried out to regain the strength of deteriorated structural concrete elements and to prevent further distress in concrete. Strength deficiency of concrete structural members can be due to poor workmanship, design errors, and deterioration due to the aggression of harmful agents.

The retrofitting process shall start with investigation and diagnosis of cracks and then applying suitable retrofitting technique and compatible materials.

There are several techniques which are used to retrofit structural members such as section enlargement, external plate bonding, external post-tensioning, grouting, and fibre reinforced polymer composites. Based on the severity of the damage and required capacity to be regained, a proper retrofitting technique is specified and implemented.

When do RCC Structural Members Need Retrofitting?

There are several problems that RCC structural members experience and needed to be tackled. Common problems include:

1. Structural cracks.
2. Damage to structural members.
3. Excessive loading.
4. Errors in design or construction.
5. Modification of structural system.
6. Seismic damage.
7. Corrosion due to penetration- honey combs

Fig. 1: Structural Cracks

Fig. 2: Structural Damage

Retrofitting Methods for RCC Structural Members

1. Fiber Reinforced polymer (FRP) composites.
2. External plate bonding.
3. Near Surface Mounted FRP bars or Strips.
4. Section enlargement. /Jacketing
5. External post-tensioning.
6. Grouting.
7. Epoxy Injection

Fig. 3: Retrofitting with FRP Composite

Fig. 4: Section Enlargement

Fig. 5: Plate Bonding

Fig.6 Column Jacketing

Factors Governing Selection of Retrofitting Methods

1. Existing concrete strength.
2. Accessibility to work areas.
3. Magnitude of strength to be enhanced.
4. Cost of Construction and maintenance.
5. Time constraints.
6. Clearance issues.
7. Seismic effect consideration.
8. Environmental aspects.

Retrofitting Strategy:

1. Specify the performance requirement for the structural member that needs to be retrofitted.
2. Then, set an overall plan from inspection phase to retrofitting method selection, the design of retrofitting structure, and execution of retrofitting work.
3. After the finalization of plan, inspect the structural element that needs to be retrofitted.
4. Evaluate the performance of the structural element based on the findings of the inspection work.
5. Check whether the structural element fulfills performance requirements.

6. If the structure does not fulfill performance requirements, and if continued use of the structure through retrofitting is desired, proceed with the design of the retrofitting structure.
7. Select an appropriate retrofitting method.
8. Specify materials to be used, structural specifications and construction method.
9. Evaluate the performance of the structure after retrofitting and verify that it fulfills performance requirements.
10. If it is determined that the retrofitting structure is capable of fulfilling performance requirements with the selected retrofitting and construction methods, implement the retrofitting work.