REHABILITATION AND RETROFITTING OF STRUCTURES
(COURSE CODE : ACE505)
REGULATION : IARE-R16
B.TECH VIII SEM

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Syllabus

- UNIT-1-Deterioration of structures; distress in structures; causes and prevention, mechanism of damage; types of damage; damage under accidental and cyclic loads, cracking in structures, evaluation of damage.

- UNIT-2-Maintenance, repair and rehabilitation, facets of maintenance, importance of maintenance, various aspects of inspection; Assessment procedure for evaluating a damaged structure; Diagnosis of construction failures.

- UNIT-3-Corrosion damage of reinforced concrete, methods of corrosion protection, corrosion inhibitors, corrosion resistant steels, cathodic protection, rust eliminators. Causes of deterioration of concrete, steel, masonry and timber structures, surface deterioration, efflorescence, causes and preventive measures; coatings for embedded steel and set concrete.

- UNIT-4-Special concrete and mortar, concrete chemicals, expansive cement, polymer concrete sulphur infiltrated concrete, ferro cement, fiber reinforced concrete, methods of repair in concrete, steel, masonry and timber structures. Gunite and shotcrete, epoxy injection.

- UNIT-5-Strengthening of existing structures; repairs to overcome low member strength, deflection, cracking, chemical disruption, weathering, wear, fire, leakage, marine exposure, use of non-destructive testing techniques for evaluation, load testing of structure, demolition of structures using engineered and non engineered techniques.

UNIT-I
INTRODUCTION

Deterioration Of Structures

Deterioration of Structures

Causes and Prevention

Possible causes of deterioration/defects

- Pre-construction stage
- Construction stage
- Post-construction stage

Deterioration Of Structures

PRE-CONSTRUCTION STAGE DEFECTS

CAUSES

- Poor design
- Poor design detailing
- Poor deflection estimations
- Faulty design of rigid joints in precast elements
- Faulty design estimations at changes in sections

CONSTRUCTION STAGE DEFECTS

SWELLING OF FORMWORK

CAUSES

- Formwork absorbs moisture from concrete or the atmosphere, which results in swelling of form.
- Crushing of wale in the formwork also causes movements of forms
- These result in cracks in the concrete while setting

PREVENTION

- Coating of the formwork with moisture resistant material.
- Using unyielding lateral ties with good end anchorage

CONSTRUCTION STAGE DEFECTS

INTERNAL SETTLEMENT OF CONCRETE

CAUSES

- Differential settlement between the surface and the interior volume of the concrete suspension causes surface cracks.
- Concrete on the surface sets faster than the interior suspension

PREVENTION

- Surface cracks can be cured and closed by delayed finishing.
- Curing of concrete must start immediately after casting to delay setting of the surface concrete.
- Good compaction will also help prevent this defect.

CONSTRUCTION STAGE DEFECTS

SETTING SHRINKAGE OF CONCRETE

CAUSES

- While setting the concrete shrinks giving rise to surfacial cracks resembling the scales of the alligator.

PREVENTION

- Good and timely curing will help avoid this type of damage.

CONSTRUCTION STAGE DEFECTS

VIBRATIONS INDUCED DAMAGES

CAUSES

- Vibrations due to indiscreet walking over concrete and dumping construction materials, etc., can also lead to cracking

PREVENTION

- Workers have to be trained in avoiding such carelessness

CONSTRUCTION STAGE DEFECTS

PREMATURE REMOVAL OF SHORES

CAUSES

- Premature removal of shores from freshly poured concrete causes re-distribution of stresses on formwork, causing movements and cracking of concrete.

PREVENTION

- Shores must be removed only after the concrete has gained sufficient strength.

POST-CONSTRUCTION STAGE DEFECTS

WEATHERING ACTION

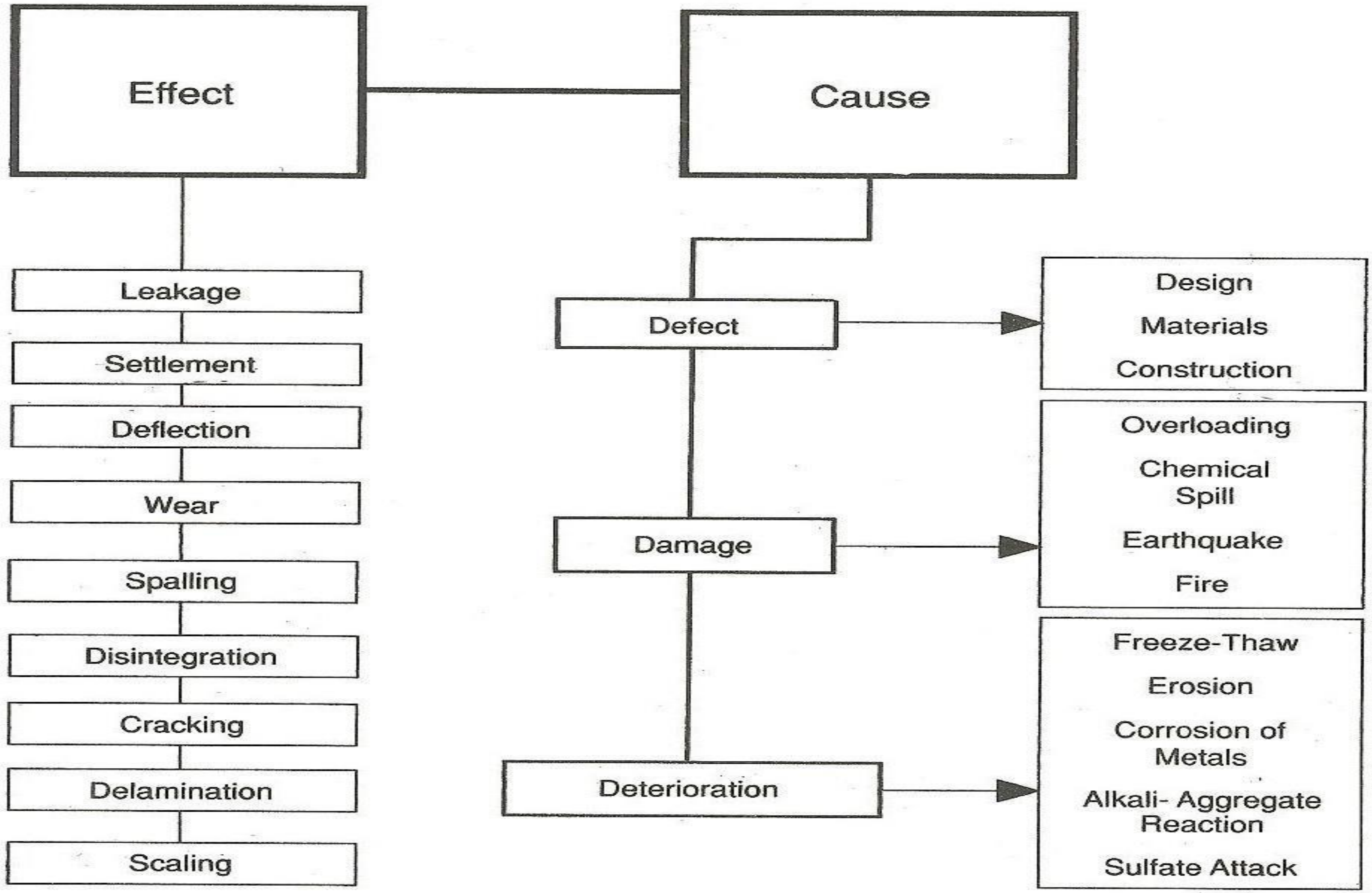
CAUSES

- Shock waves
  - Shock waves could be mechanical or thermal
  - Concrete is heterogeneous - different constituents have different wave transmission rates
- Erosion

PREVENTION

- Providing sufficient reinforcement is said to an excellent resistance to shock waves.
- Use of high-strength concrete
- Proper curing
- Proper finishing

Deterioration Of Structures



Distress in Structures

Distress in Structures

Structural

- Caused by faulty design, faulty construction and/or overloading.
- Endangers building safety.
- Needs immediate attention.

Non-Structural

- Caused by internally induced stresses in components
- Looks unsightly
- Indirectly leads to structural weakening

Factors Causing distress

External

- Overloads due to dead load, live load, wind load, seismic loads, etc. which are not accounted in the design.
- Differential settlements in the foundation.

Internal

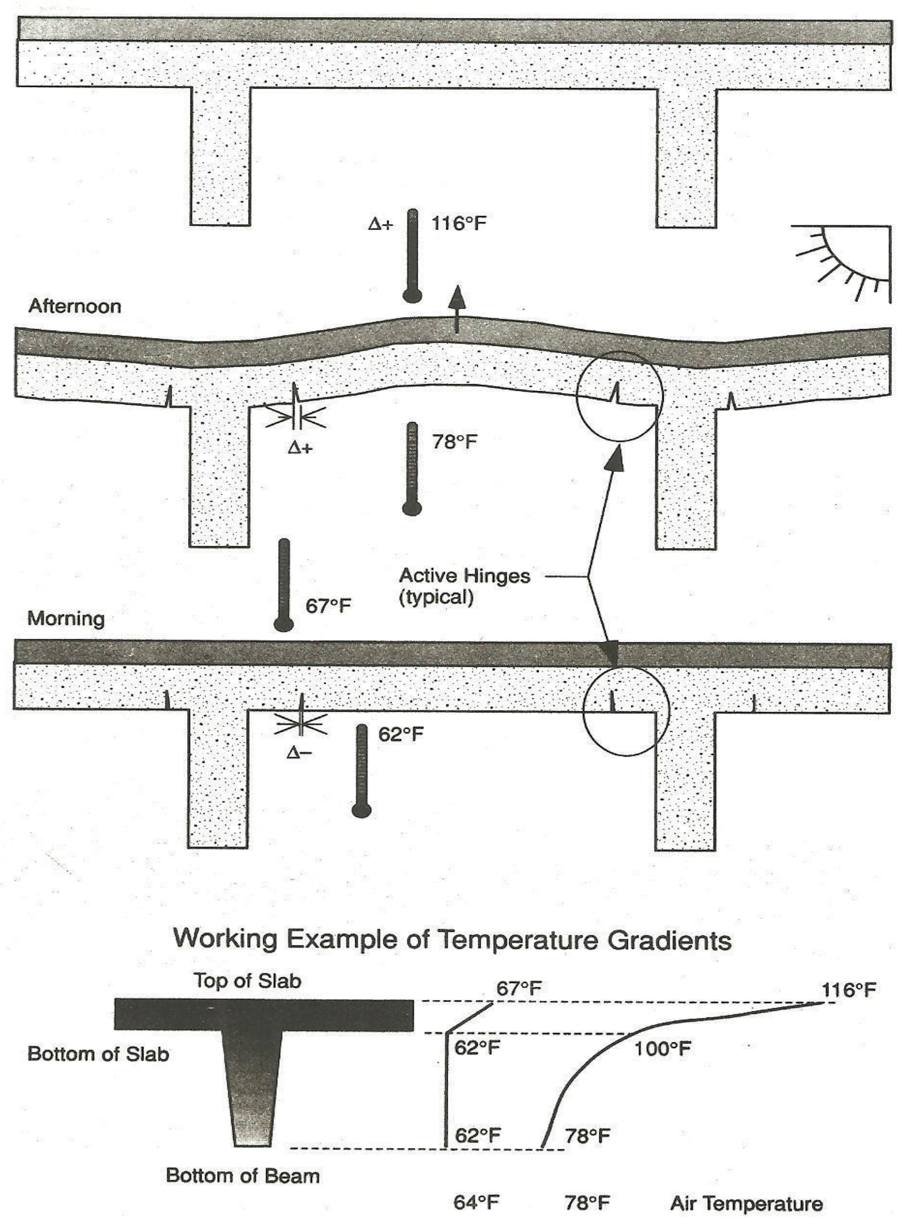
- Dimensional changes induced by
  - moisture penetration
  - temperature changes
  - horizontal shifts of building components
  - volume changes due to chemical action
- Weakness in tensile and shear stresses

Thermal Cause: (B)Temperature Variation

Diurnal Solar Heating effects the structure based on its configuration.

In simple span structures only up and down deflections take place and the joints are free to rotate.

In continuous span structures, hinges may form due to joint rotation being restrained. These hinges open and close with daily temperature.



DAMAGE IN HARDENED CONCRETE

TYPE 3:THERMAL CAUSE

(C) Early Thermal Cracking in Fresh Concrete

DAMAGE IN HARDENED CONCRETE

Thermal Cause: (C) Early thermal contraction

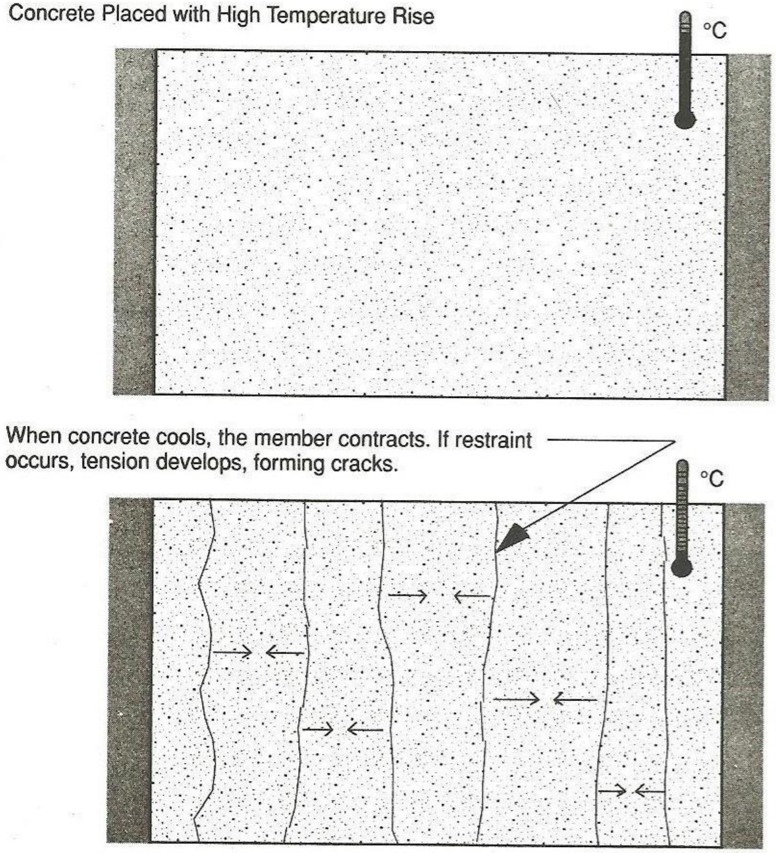
Fresh concrete undergoes temperature rise due to cement hydration.

When concrete is cooling to the surrounding ambient temperature in a few days, the concrete has very little tensile strength.

Weak tensile strength + thermally contracting concrete = tension cracks

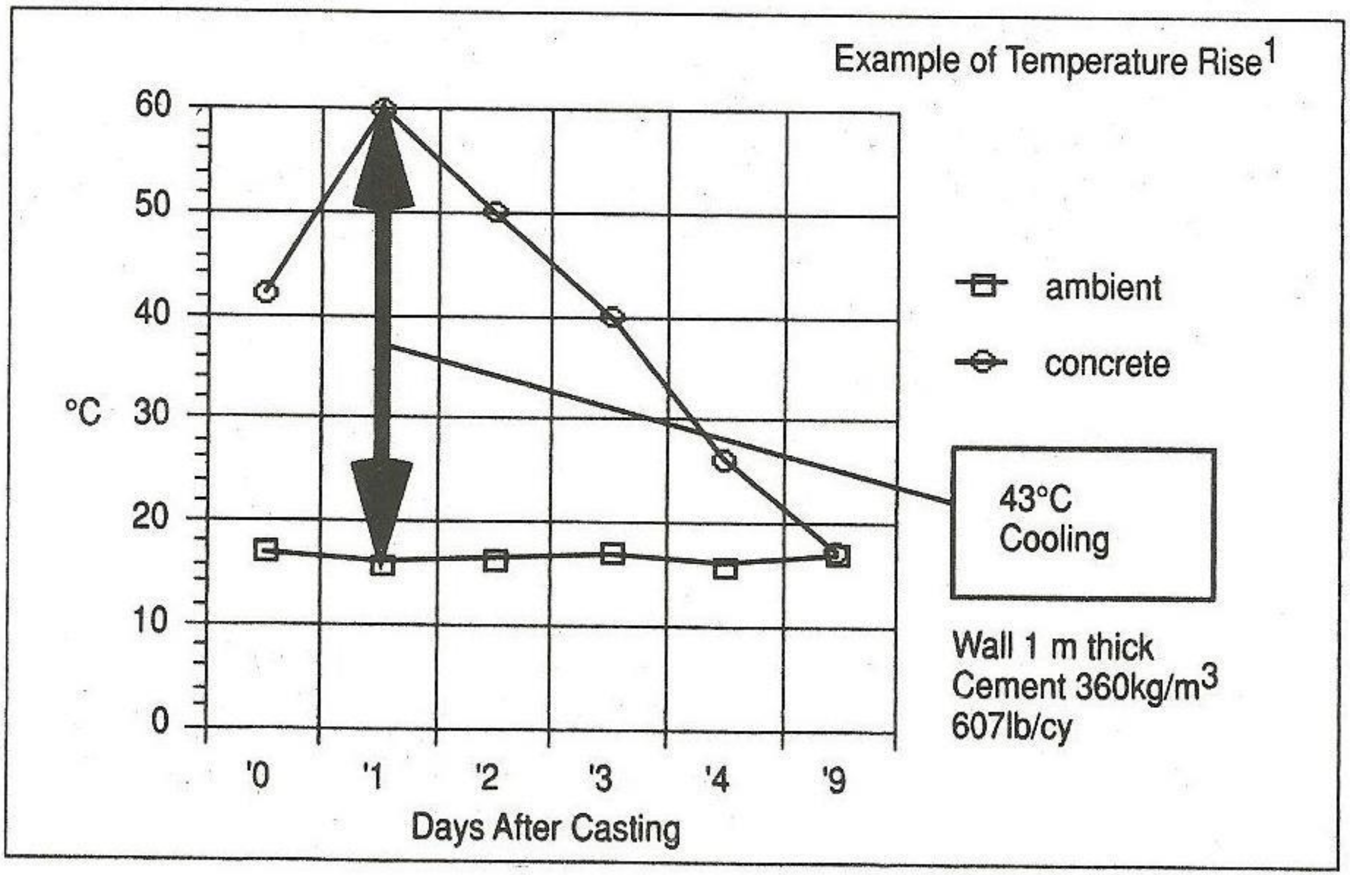
DAMAGE IN HARDENED CONCRETE

Thermal Cause: (C) Early thermal contraction



DAMAGE IN HARDENED CONCRETE

Thermal Cause: (C) Early thermal contraction



Thermal Cause: (C) Early thermal contraction

Factors affecting early temperature rise in fresh concrete

- **Initial temperature of materials:** Warm materials lead to warm concrete. Aggregate temperature is most critical.
- **Ambient temperature:** Higher ambient temperature leads to higher peaks
- **Dimensions:** Large sections generate more heat.
- **Curing:** Water curing dissipates the build-up of heat. Avoid thermal shock.
- **Formwork removal:** Early removal of formwork reduces peak temperature.

- **Type of formwork:** Wood form produces higher temperatures than steel forms.
- **Cement Content:** More cement in the mix means more heat.
- **Admixtures:** Fly ash reduces the amount of heat build-up
- **Cement Type:** Type III cement produces more heat than most other cements

UNIT-II
MAINTENANCE AND DIAGNOSIS OF FAILURE

Maintenance:

- Maintenance is the act of keeping something in good condition by checking or repairing it regularly.

Repair:

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

Rehabilitation:

- Rehabilitation is the process of returning a building or an area to its previous good conditions.

Facets of maintenance

The two facets of maintenance are

i) Prevention

ii) Repair

Importance of Maintenance

- It helps to identify the cause of failure, e.g whether the failure is due to design defect or a wear out failure.
- It also helps in deciding the type of maintenance and maintenance decision like replace and repair.
- It provides the necessary information regarding the life and reliability of the equipment.

a) Daily Routine Maintenance:

- Basically an inspection oriented and may not contain action to be taken.
- Help in identifying major changes, development of cracks, identifying new cracks etc.,
- Inspection of all essential items by visual observation.
- Check on proper function of sewer, water lines, wash basins, sinks etc.,
- Check on drain pipes from roof during rainy season.

b) Weekly Routine Maintenance

- Electrical accessories
- Cob webs cleaning
- Flushing sewer line
- Leakage of water line

c) Monthly Routing Maintenance:

- Cleaning doors, windows latches etc
- Checking septic tank/ sewer
- Observation for cracks in the elements
- Cleaning of overhead tanks
- Peeling of plaster, dampness, floor cracks

d)Yearly Routine Maintenance:

- Attending to small repairs and white washing
- Painting of steel components exposed to weather
- Check of displacements and remedial measures

Various aspects of Inspection

The following are the various maintenance aspects,

a) Daily Routine Maintenance

b) Weekly Routine Maintenance

c) Monthly Routine Maintenance

d) Yearly Routine Maintenance

Assessment Procedure for Evaluating Damages in Structure and Repair techniques:

For assessment of damage of a structure the following general considerations have to be take account.

1) Physical inspection of damaged structure.
2) Presentation and documenting the damage.
3) Collection of samples and carrying out tests both in situ and in lab.
4) Studying the documents including structural aspects.
5) Estimation of loads acting on the structure.
6) Estimate of environmental effects including soil structure interaction.
7) Diagnosis.

UNIT-III
DAMAGES AND THEIR REMEDIES

Corrosion Damage of Reinforced Concrete

- The damage to the Concrete due to corrosion of reinforcement is considered to be one of the most serious problems. It is an universal problem and property worth of crores of rupees is lost every year .
- Due to corrosion problem in bridges, buildings and other RCC structures, India incurs heavy loss of about Rs.1500 crores annually.

Classification of corrosion protection methods:

- Active corrosion protection
- Passive corrosion protection
- Permanent corrosion protection
- Temporary corrosion protection

1) Active corrosion protection:

The aim of active corrosion protection is to influence the reactions which proceed during corrosion, it being possible to control not only the package contents and the corrosive agent but also the reaction itself in such a manner that corrosion is avoided. Examples of such an approach are the development of corrosion-resistant alloys and the addition of inhibitors to the aggressive medium.

2) Passive corrosion protection

In passive corrosion protection, damage is prevented by mechanically isolating the package contents from the aggressive corrosive agents, for example by using protective layers, films or other coatings. However, this type of corrosion protection changes neither the general ability of the package contents to corrode, nor the aggressiveness of the corrosive agent and this is why this approach is known as passive corrosion protection. If the protective layer, film etc. is destroyed at any point, corrosion may occur within a very short time.

3) Permanent corrosion protection

The purpose of permanent corrosion protection methods is mainly to provide protection at the place of use. The stresses presented by climatic, biotic and chemical factors are relatively slight in this situation. Machines are located, for example, in factory sheds and are thus protected from extreme variations in temperature, which are frequently the cause of condensation. Examples of passive corrosion protection methods are:

- Tin plating
- Galvanization
- Coating
- Enameling
- Copper plating

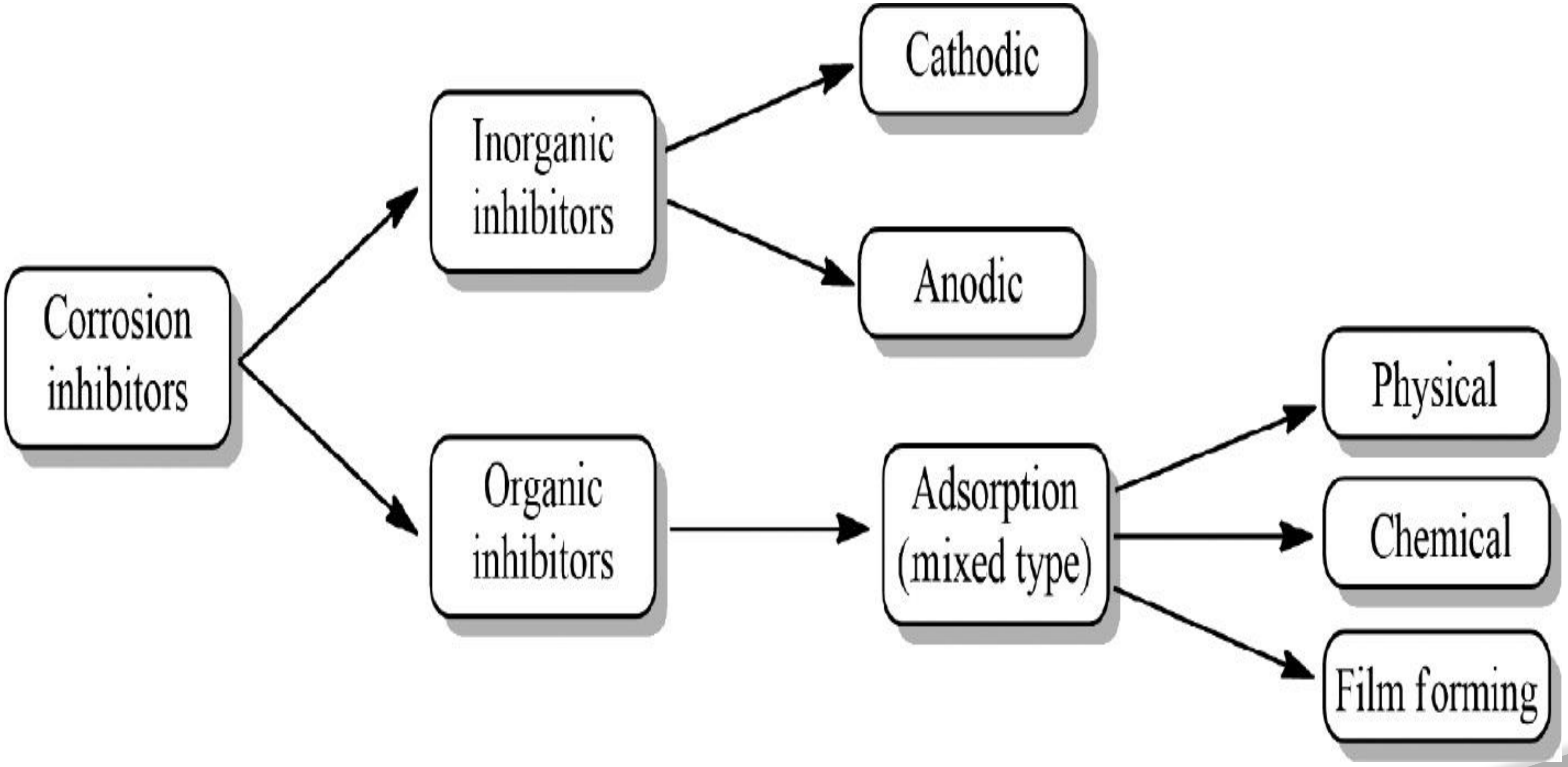
4)Temporary corrosion protection:

The stresses occurring during transport, handling and storage are much greater than those occurring at the place of use. Such stresses may be manifested, for example, as extreme variations in temperature, which result in a risk of condensation. Especially in maritime transport, the elevated salt content of the water and air in so-called sea salt aerosols may cause damage, as salts have a strongly corrosion-promoting action.

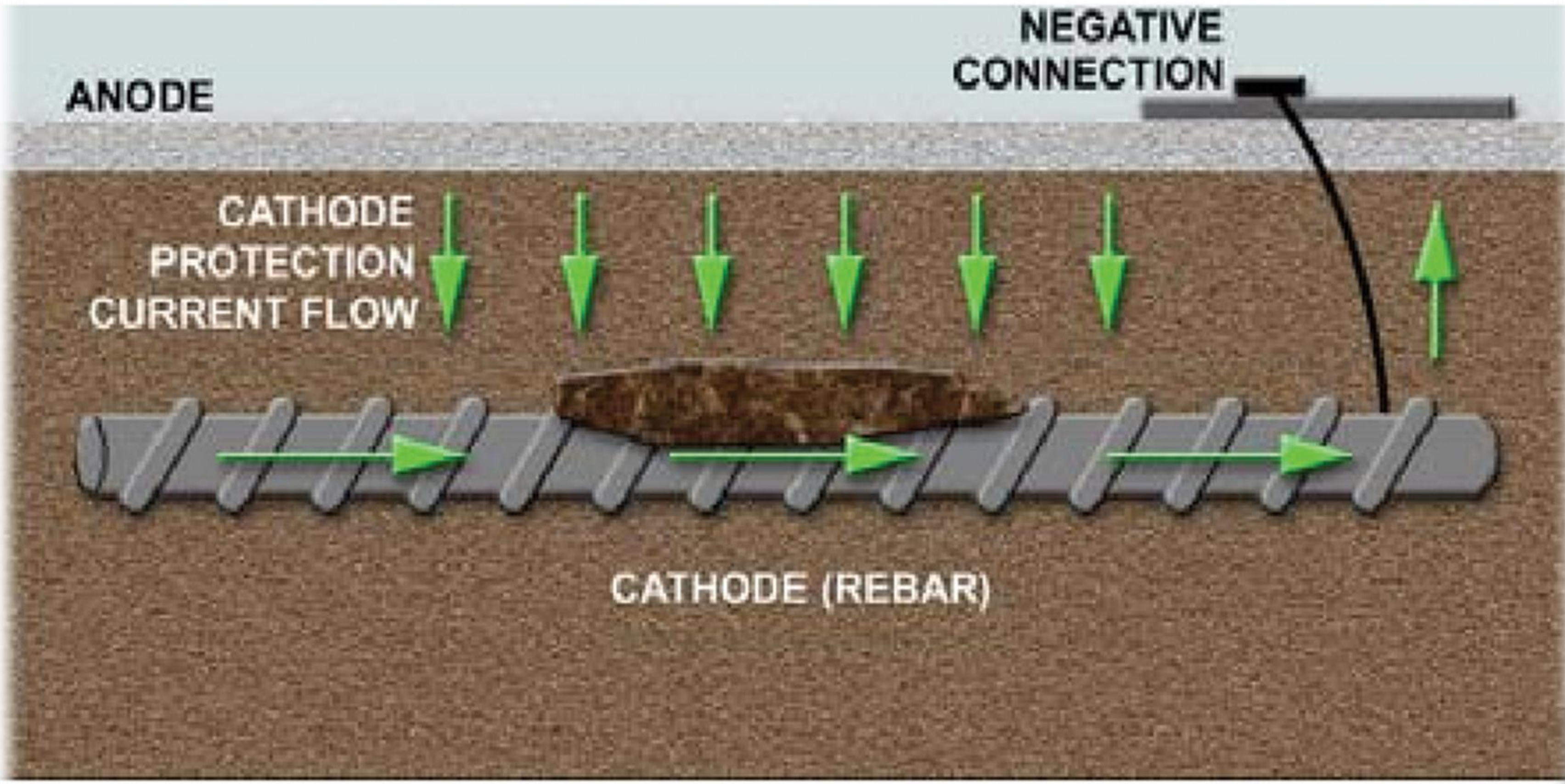
The following are the main temporary corrosion protection methods:

- Protective Coating Method
- Desiccant Method
- VCI Method

Classification of Corrosion Inhibitors:



Cathodic Protection of Steel in Concrete:



Causes Of Concrete Deterioration

1. Spalling
2. Cracking
3. Debonding of the Joints
4. Erosion
5. Corrosion of Concrete Through Chemical Attack
6. Sagging of Beams and Floors, bowing or inclination
7. Excessive Efflorescence, staining or discoloration
8. Damages Due to Vibration
9. Faults in Design, Material, and Workmanship

Efflorescence

Efflorescence is a crystalline deposit of salts that can form when water is present in or on brick, concrete, stone, stucco or other building surfaces. It has a white or greyish tint and consists of salt deposits left behind when water evaporates. In addition, efflorescence can appear as a powdery substance on floors and walls and requires special care to treat.

Causes of Efflorescence

- Water-soluble salts must be present.
- Moisture must be available to transform salts into a soluble solution.
- Salts must be able to move through a material to its surface. The moisture will then evaporate and cause the salts to crystallize, resulting in efflorescence.

Preventive measures for Efflorescence

There are many solutions to prevent efflorescence, including:

- **Hydrophobic Sealant:** Applying an impregnating hydrophobic sealant to a building material surface can prevent the absorption of water. The sealant also will stop water from travelling within a building material.
- **Capillary Breaks:** Installing capillary breaks such as polyethylene sheeting between a building material and soil can minimize the risk of salt entering the material.
- **Quality Masonry Construction:** Implementing overhanging copings, eaves and flashings will minimize the risk of water from entering a wall.

- **Increased Emphasis on Landscaping and Sprinklers:**

  Paying special attention to landscaping and sprinklers will ensure you can prevent water from reaching porous building materials.

- **Installing Grout With Mechanical Vibration:**

  Consolidating grout with mechanical vibration will limit the chance of voids in the grout.

- **Using Dense Tooled Mortar Joints:**

  Leveraging dense tooled mortar joints reduces the porous nature of a wall, making it tough for salts to migrate through it.

UNIT-IV
MATERIALS AND TECHNIQUES OF REPAIR

Special Concrete

General:

- Special Concrete are the concrete prepared for specific purpose like Light weight, high density, fire protection, radiation shielding etc., Concrete is a versatile material possessing good compressive strength. But it suffers from many drawbacks like low tensile strength, permeability to liquids, corrosion of reinforcement, susceptibility to chemical attack and low durability.
- Modification have been made from time to time to overcome the deficiencies of cement concrete. The recent developments in the material and construction technology have led to significant changes resulting in improved performance, wider and more economical use.

Different types of Special Concrete

1. Light weight Concrete
2. High density concrete
3. Plum concrete
4. No fines concrete
5. Aerated concrete
6. Fiber reinforced concrete
7. Polymer concrete
8. Ferro cement
9. High strength concrete
10. High performance concrete

Types of Concrete Chemicals (Admixtures):

Based on their functions, admixtures can be classified into the following five major categories:

- Retarding admixtures
- Accelerating admixtures
- Super plasticizers
- Water reducing admixtures
- Air-entraining admixtures

Expansive Concrete:

Expansive cement is special type of cement when mixed with water, which forms a paste that tends to increase in volume to a significantly greater degree than Portland cement paste after setting. The expansion of the cement mortar or concrete is compensated for the shrinkage losses.

Uses of Expansive Cement:

- This cement is used in large, continuous floor slabs without joints.
- It work well to fill holes in foundations and to create self-stressed concrete that is stronger than conventional portland cement concrete.
- Pre-stressed concrete components for bridges and buildings are made using this material.
- Used for construction of water retaining structures and also for repairing the damaged concrete surfaces.
- Used in grouting of anchor bolts.

Polymer Concrete:

- Polymer Concrete is an ordinary concrete produced with OPC (Ordinary portland cement) wet cured and inseminated with liquid or vaporous chemical compound (Methyl methacrylate monomer) and polymerized by gamma radiation or with chemical initiated implies, i.e by utilizing thermal catalytic method (Adding 3% Benzoyl peroxide) to the monomer as a catalyst. The impregnation is helped by drying the concrete at an extreme temperature by evacuations and absorbing the monomer under limited pressure.

Ferro Cement:

Ferro cement is a type of thin wall reinforced concrete , commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials.

Materials used in Ferro Cement:

- Cement mortar mix
- Skeleton steel
- Steel mesh reinforcement

Methods of Concrete Crack Repair:

There are several methods of concrete crack repair such as

- Epoxy injection,
- Routing and sealing,
- Grouting,
- Stitching,
- Drilling and plugging,
- Gravity filling of cracks in concrete.

Gunite and shotcrete :

Gunite and shotcrete are two trade terms for different types of sprayed concrete. Sprayed concrete was developed as a construction solution for tunnels, underground structures, slope stabilization, structural repairs, and swimming pools. The process involves a mortar or small-aggregate concrete that is sprayed with air power onto surfaces at a high velocity. The force of the concrete spray consolidates and compacts the material and ensures that it adheres to the host surface.

UNIT-V
STRENGTHENING AND DEMOLITION ASPECT

Methods of Strengthening Concrete Columns:

There are three major techniques for strengthening reinforced concrete columns are:

1. Reinforced Concrete Jacketing
2. Steel Jacketing
3. FRP Confining or Jacketing

Reinforced Concrete Jacketing Process

- Initially, reduce or eliminate loads on columns temporarily if it is required. This is done by putting mechanical jacks and additional props between floors.
- After that, if it is found out that reinforcements are corroded, the remove the concrete cover and clean the steel bars using a wire brush or sand compressor.
- Then, coat the steel bars with an epoxy material that would prevent corrosion.
- If reducing loads and cleaning reinforcement is not needed, the jacketing process begin by adding steel connectors into the existing column.

- The steel connectors are added into the column by making holes 3-4mm larger than the diameter of the used steel connectors and 10-15cm depth.
- The spacing of new stirrups of the jacket in both the vertical and horizontal directions should not be more than 50cm.
- Filling the holes with an appropriate epoxy material then inserting the connectors into the holes.
- Adding vertical steel connectors to fasten the vertical steel bars of the jacket following
- Installing the new vertical steel bars and stirrups of the jacket according to the designed dimensions and diameters.

- Coating the existing column with an appropriate epoxy material that would guarantee the bond between the old and new concrete.
- Pouring the concrete of the jacket before the epoxy material dries. The concrete used should be of low shrinkage and consists of small aggregates, sand, cement and additional materials to prevent shrinkage. Steps of reinforced concrete jacketing are illustrated in Fig.

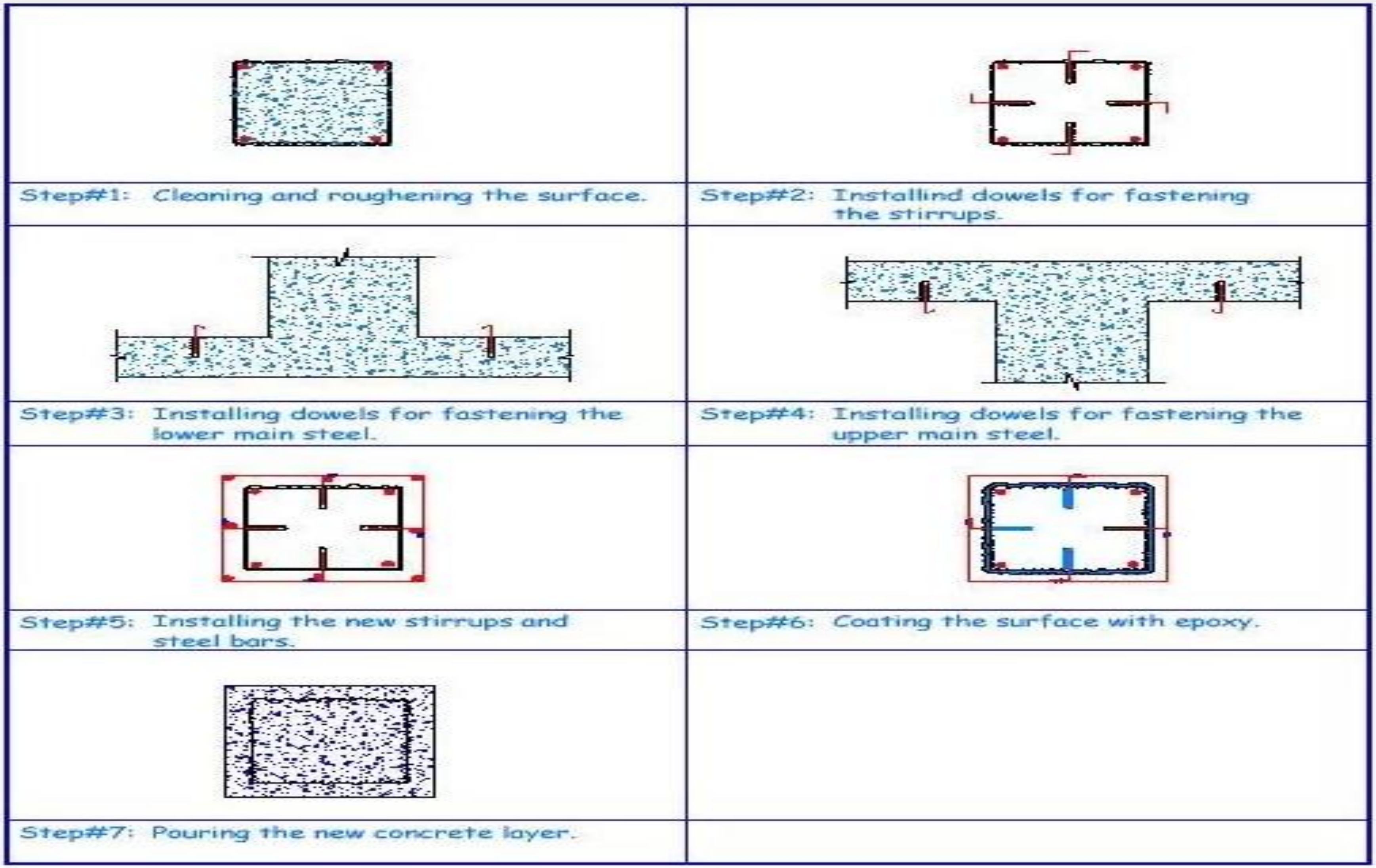


Fig. 1: Increasing the Cross-sectional Area of Column by RC Jacketing

Steel Jacketing

- Removing the concrete cover.
- Cleaning the reinforcement steel bars using a wire brush or a sand compressor.
- Coating the steel bars with an epoxy material that would prevent corrosion.
- Installing the steel jacket with the required size and thickness, according to the design, and making openings to pour through them the epoxy material that would guarantee the needed bond between the concrete column and the steel jacket.
- Filling the space between the concrete column and the steel jacket with an appropriate epoxy material.

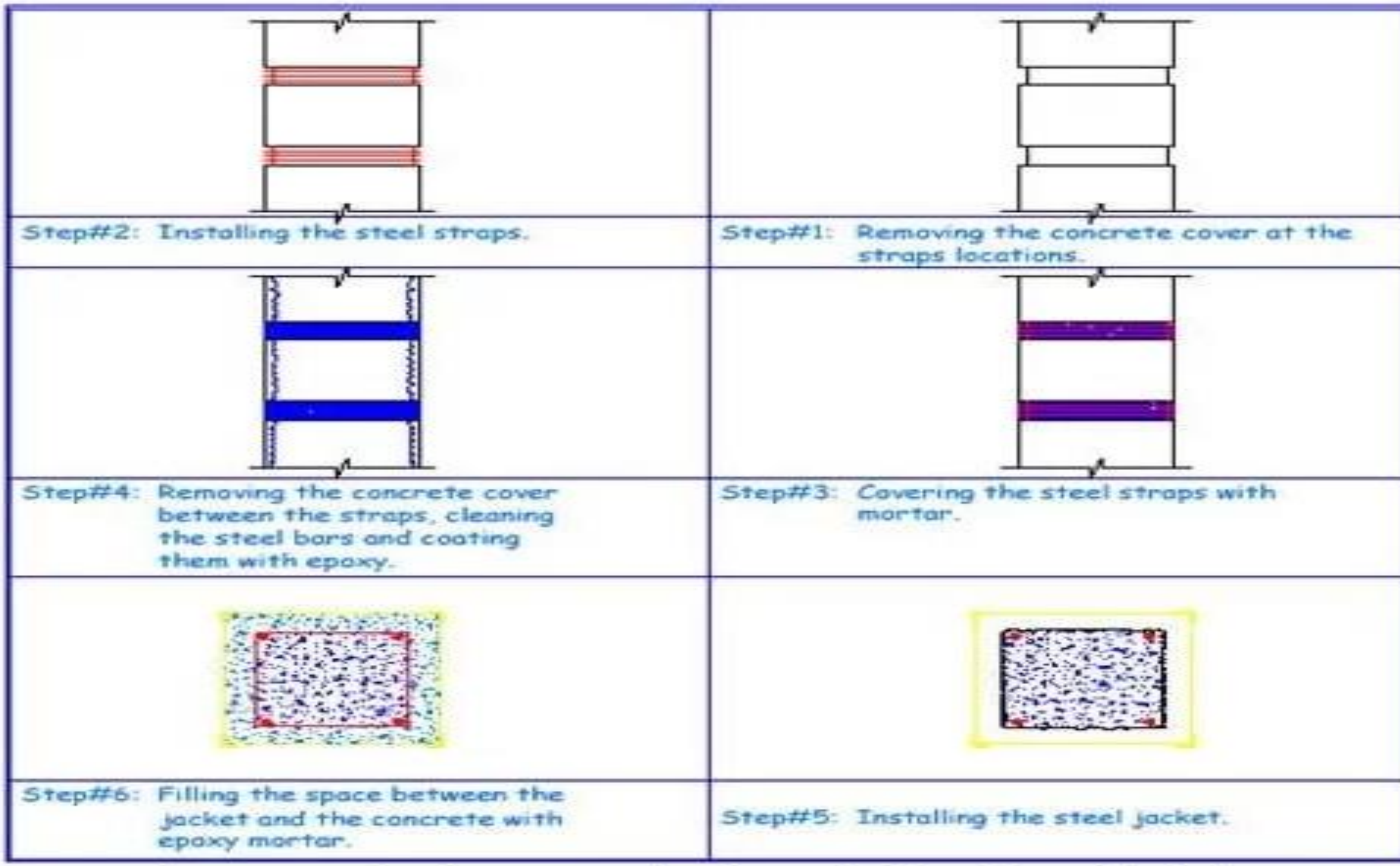
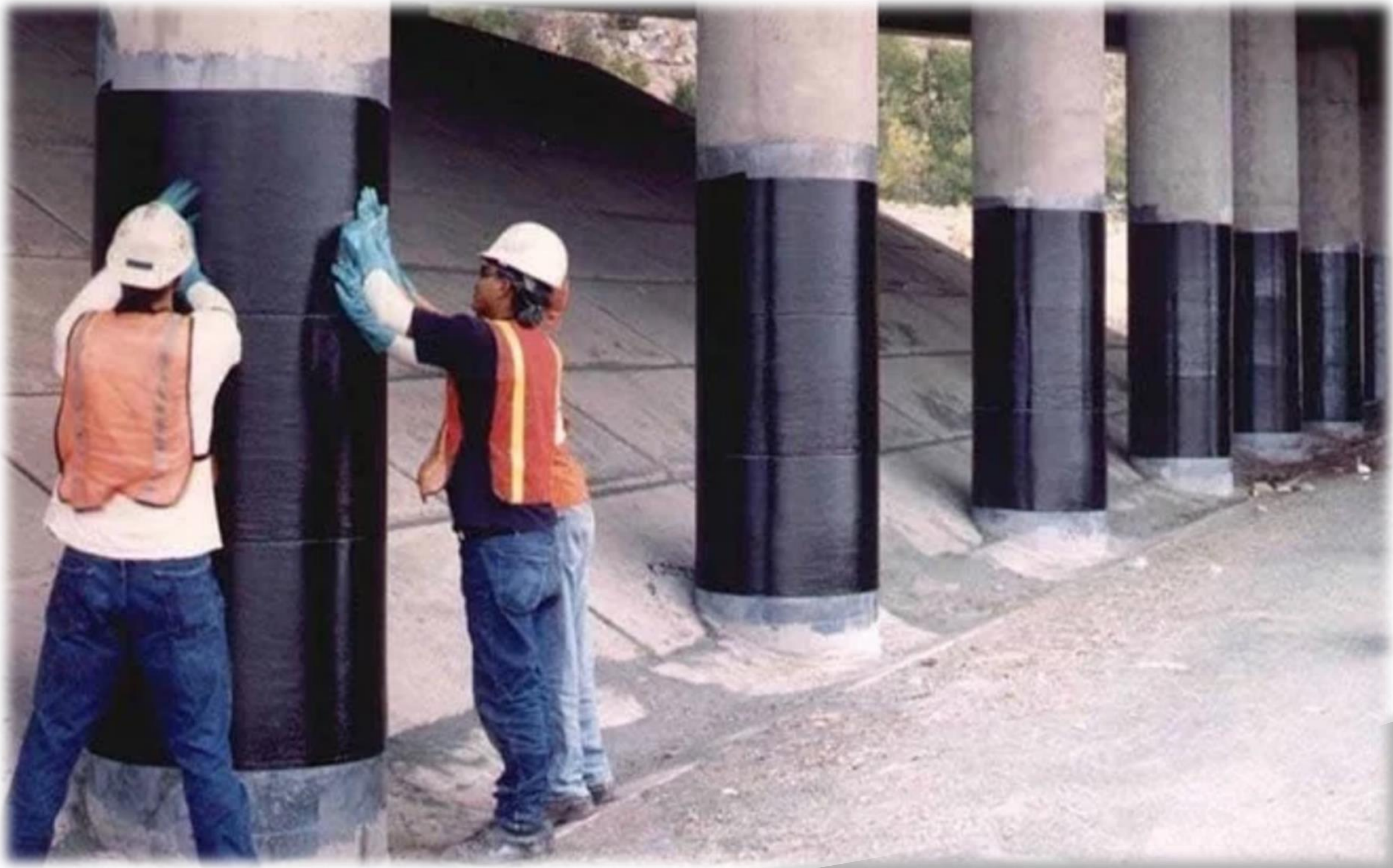


Fig. 2: Increasing the cross-sectional area of column by steel jacketing

Fig. 3: Column strengthened with steel angles

Fig. 4: Welding steel jacket

FRP Confining:



Strengthening Of Reinforced Concrete Beams:

- Adding Reinforcement Steel Bars To The Main Steel Without Increasing The Beam's Cross Sectional area.
- Increasing both the reinforcing steel bars and the cross – sectional area of concrete
- Adding steel plates to the beam

Adding Reinforcement Steel Bars To The Main Steel Without Increasing The Beam's Cross Sectional area:

This solution is carried out when the reinforcing steel bars are not capable to carry the stresses applied to the beam. The following steps should be followed:

- The concrete cover is removed for both the upper and lower steel bars.
- The steel bars are well cleaned and coated with an appropriate material that would prevent corrosion.
- Holes are made, in the whole span of the beam under the slab, as shown in Fig.1, 15-25cm apart, a diameter of 1.3cm and extend to the total width of the beam.

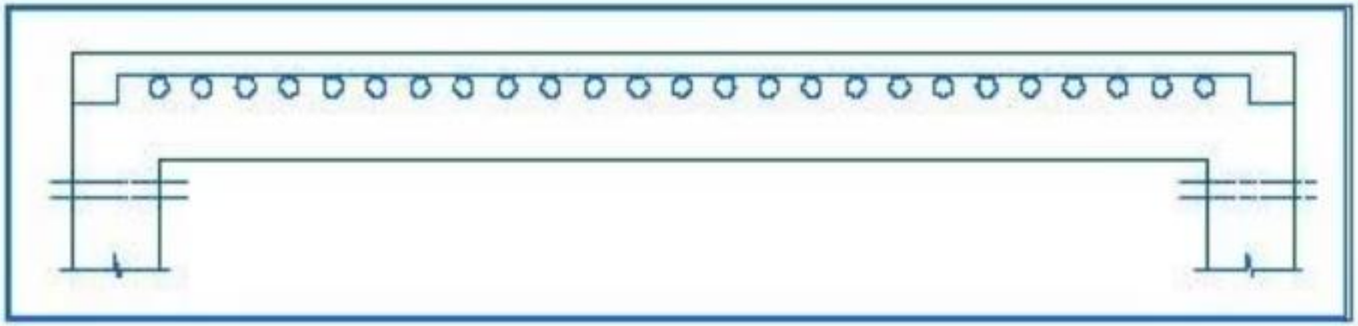


Fig. Holes in the span of a beam

- The holes are filled with an epoxy material with low viscosity and installing steel connectors for fastening the new stirrups.
- Steel connectors are installed into the columns in order to fasten the steel bars added to the beam.

- The added stirrups are closed using steel wires and the new steel is installed into these stirrups.
- The surface is then coated with a bonding epoxy material.
- The concrete cover is poured over the new steel and the new stirrups.
- The previous steps are illustrated in Fig

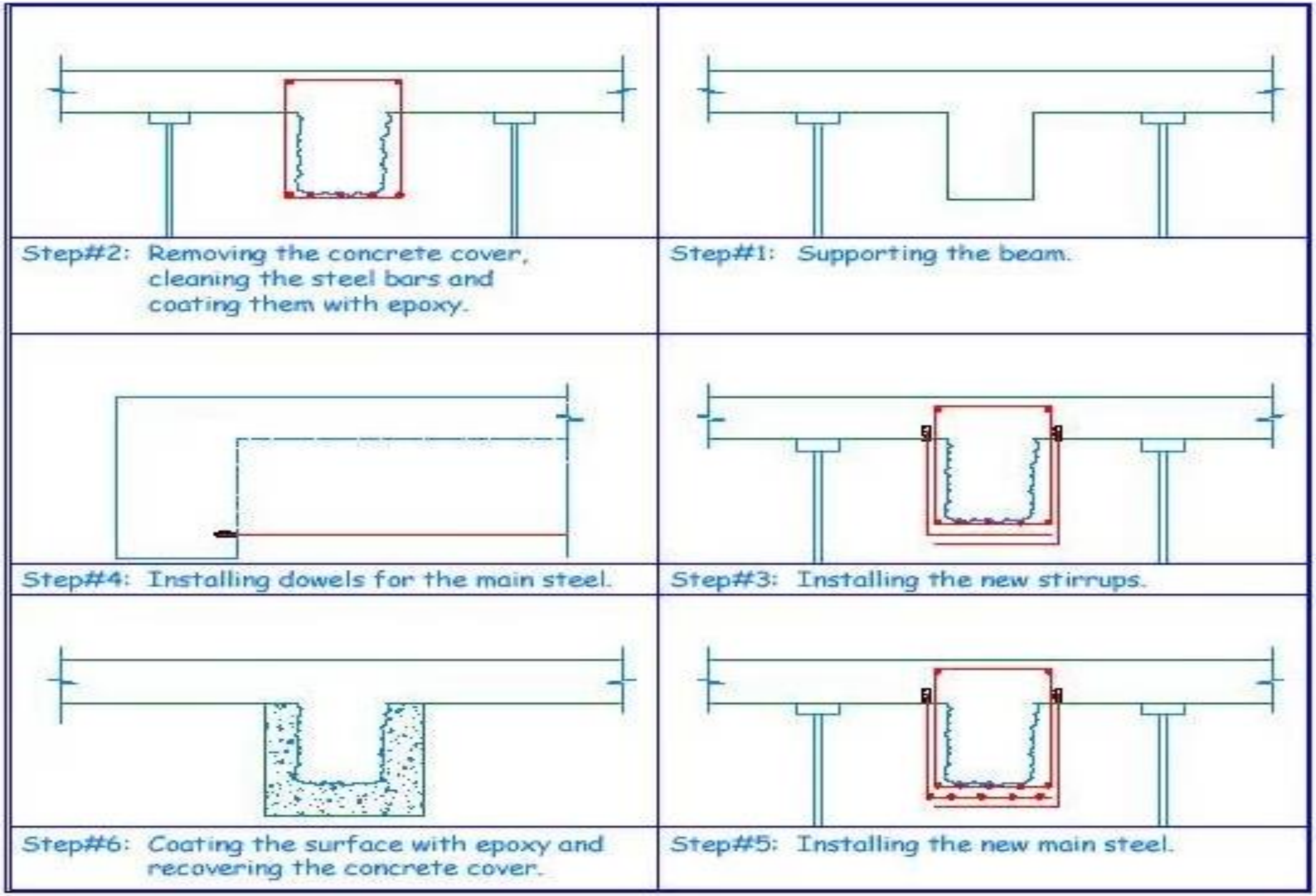


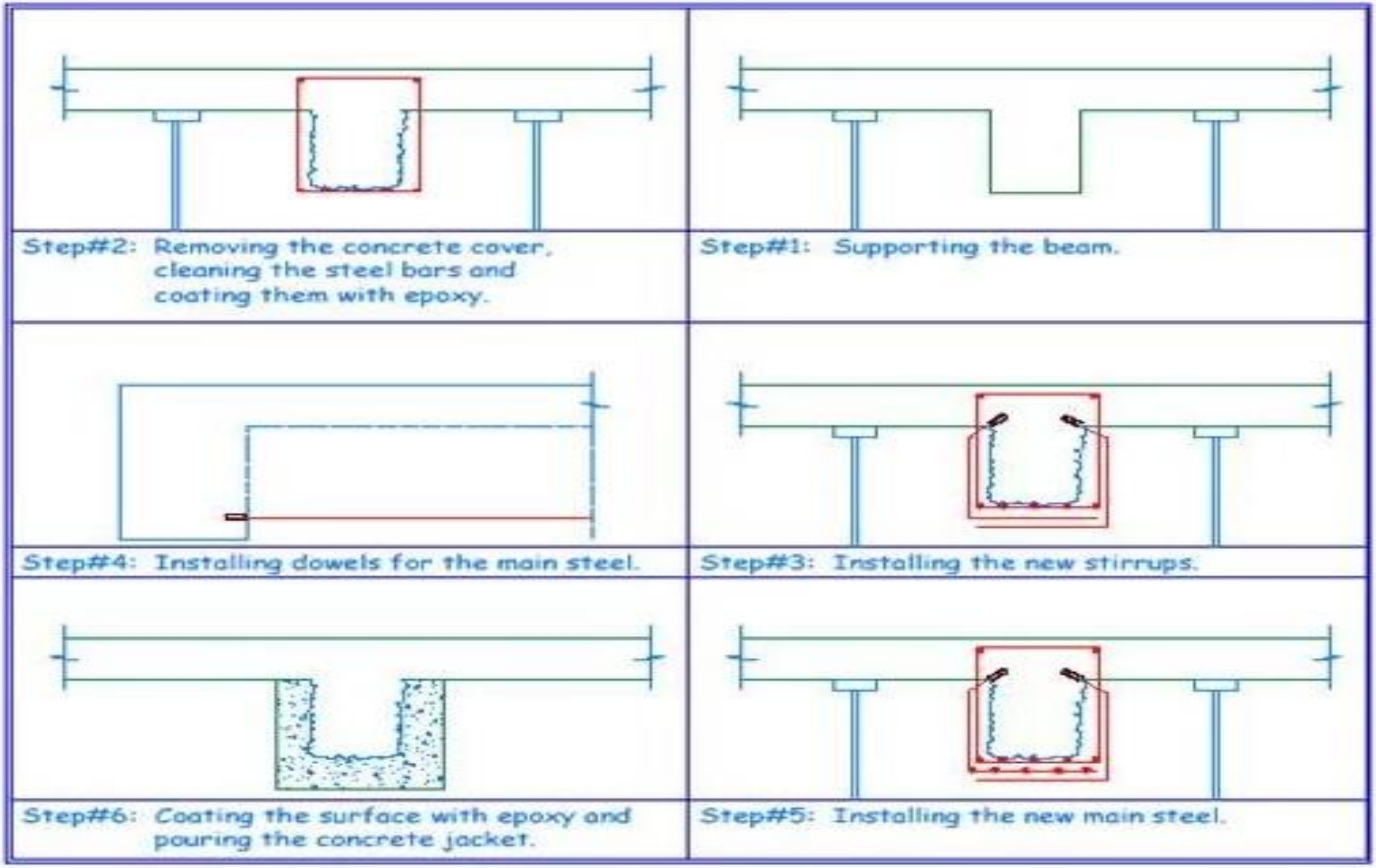
Fig. Strengthening a beam without increasing cross sectional area.

Increasing both the reinforcing steel bars and the cross – sectional area of concrete:

This solution is chosen when both the steel and concrete are not able to carry the additional loads applied to the beam. In such cases the following steps should be followed as in Fig

- Removing the concrete cover, roughing the beams surface, cleaning the reinforcement steel bars and coating them with an appropriate material that would prevent corrosion.
- Making holes in the whole span and width of the beam under the slab at 15-25cm.
- Filling the holes with cement mortar with low viscosity and installing steel connectors for fastening the new stirrups.

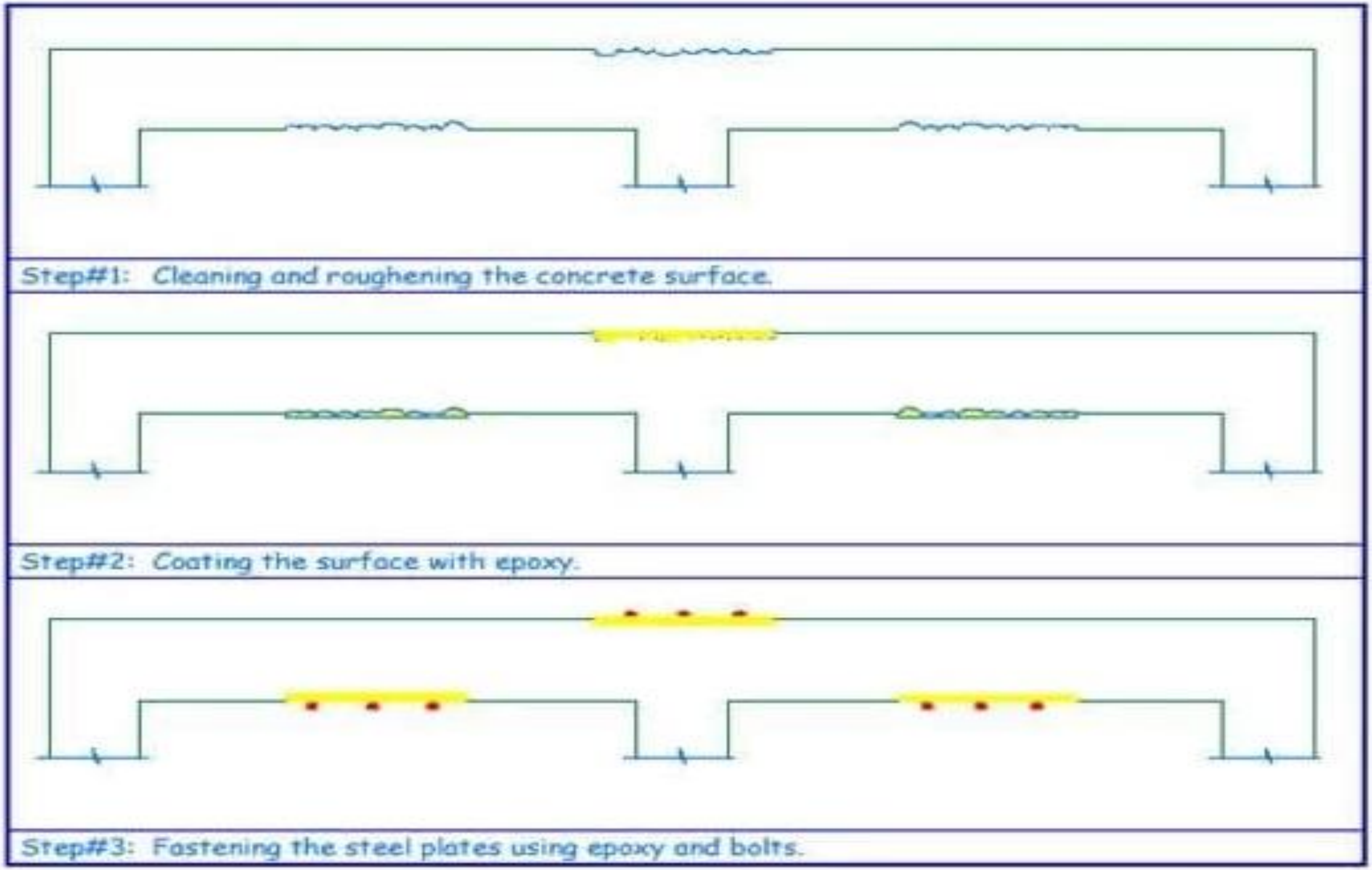
- Installing the steel connectors into the columns in order to fasten the steel bars added to the beam.
- Closing the added stirrups using steel wires and the new steel is installed into these stirrups.
- Coating the concrete surface with an appropriate epoxy material that would guarantee the bond between the old and new concrete, exactly before pouring the concrete.
- Pouring the concrete jacket using low shrinkage concrete.


Step#2: Removing the concrete cover, cleaning the steel bars and coating them with epoxy.
Step#1: Supporting the beam.
Step#4: Installing dowels for the main steel.
Step#3: Installing the new stirrups.
Step#6: Coating the surface with epoxy and pouring the concrete jacket.
Step#5: Installing the new main steel.

Adding steel plates to the beam:

When it is required to strengthen the beam's resistance against the applied moment or shear stress, steel plates are designed with the appropriate size and thickness

- Then those plates are attached to the beam as follows:
- Roughing and cleaning the concrete surfaces where the plates will be attached.
- Coating the concrete surfaces with a bonding epoxy material.
- Making holes in the concrete surfaces and plates.
- Putting a layer of epoxy mortar on top of the plates with a 5mm thickness.
- Attaching the steel plates to the concrete using bolts.



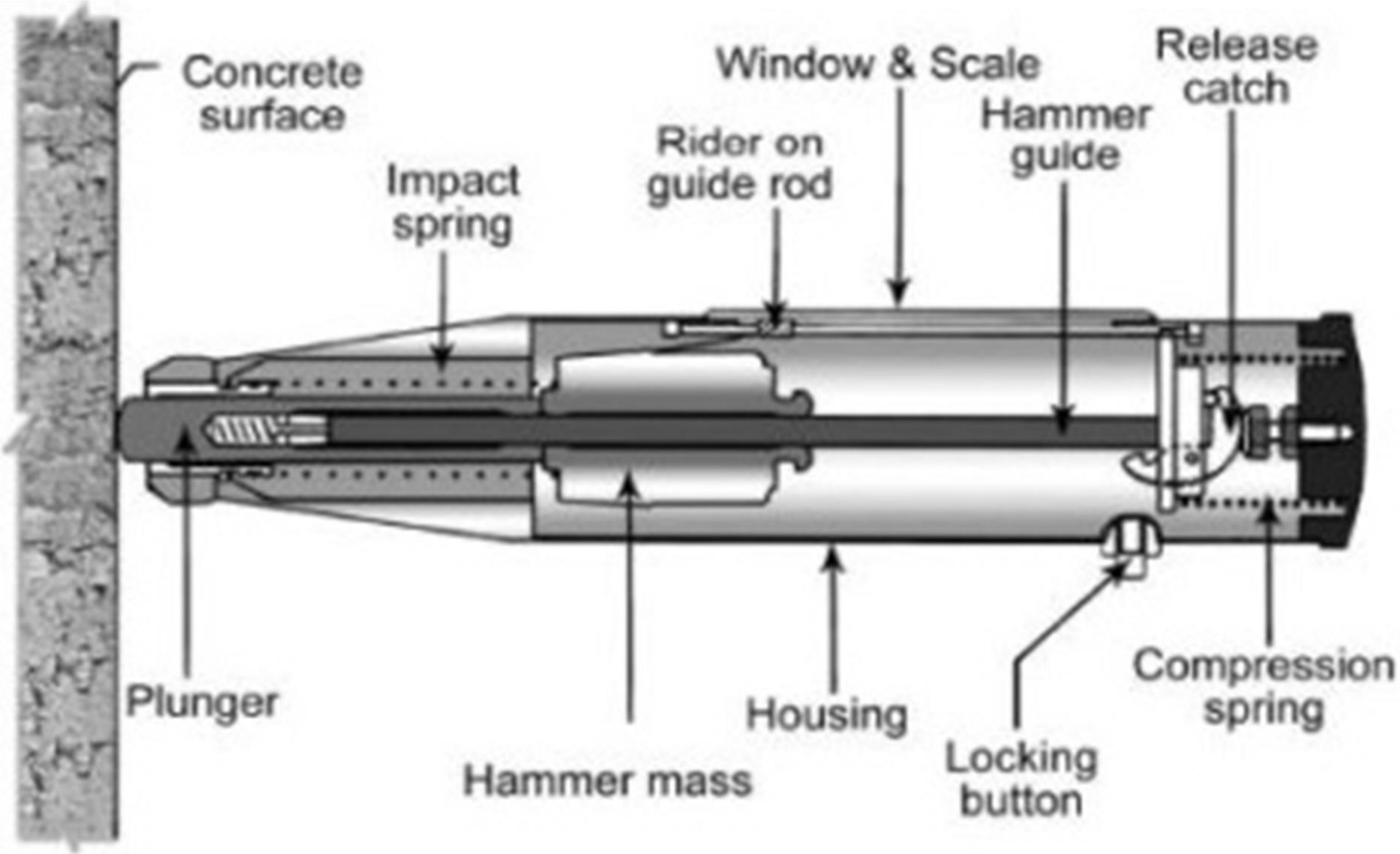
Strengthening of Beam by adding steel plates

Uses of Non Destructive Tests:

- Flaw Detection and Evaluation
- Leak Detection
- Location Determination
- Dimensional Measurements
- Structure and micro structure characterization
- Estimation of Mechanical and Physical Properties
- Stress (Strain) and Dynamic Response Measurements
- Material Sorting and Chemical Composition Determination

Rebound Hammer Test

- The surface hardness method consists of impacting the concrete surface in a standard manner. Activating a mass by a given energy and measuring the indentation or rebound achieve this. The most commonly and widely used instrument is a "Rebound Hammer".
- There are several types of hammers having varying impact energy from 0.07 kg m to 3 kg m the high impact energy is used for mass concrete, road pavements and airport runways. The low impact energy hammers (0.07 to 0.09 kg m) are used for small and low strength materials. A typical rebound hammer is shown in figure.


Concrete
surface
Impact
spring
Rider on
guide rod
Window & Scale
Hammer
guide
Release
catch
Plunger
Hammer mass
Housing
Locking
button
Compression
spring

- **Test procedure:**

The test procedure consists of applying the hammer on the concrete surface and observing the rebound reading indicated by a rider over a scale. Before applying the hammer, the surface of the concrete is cleaned and smoothened. A minimum of 10 readings is compared and each reading should not differ by more than 7 units. The average of remaining readings is determined for evaluating the strength. If more than two reading differ from the average units, than the entire set of readings are taken afresh.

- The procedure for determining the rebound values has been specified in ASTM C 805-85 BIS-1331l Part 2 and also in the latest ASTM specification. Estimation of concrete compressive strength from rebound number is determined from standard calibration curve based on the laboratory results. The calibration curve should be established for each type of concrete.

The following table shows the quality of concrete cover from rebound number.

Average rebound number	**Quality of Concrete**
Greater than 40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
Less than 20	Poor concrete
0	delaminated

- **Ultrasonic pulse Velocity (USPV) test**

  It is most widely used test in evaluation of in-situ concrete. The method is based on the principle that the velocity of an ultrasonic pulse through any material depends upon the density, modulus of elasticity, the presence of the reinforcing steel & poision's ratio of the material.

Procedure For Upv Test

- Divide the members into well defined grid points - spacing of 200 - 300 mm preferred identical to rebound hammer survey
- Each grid point is prepared to obtain smooth surface - a thorough cleaning
- Application of acoustical coupling - grease, thick oil, petroleum jelly
- Transmitting the pulses by placing the transmitter and receiving at other end (50-54 kHz)
- Recording the transit time displayed by the instrument - a reliable steady reading to be recorded
- Measurement of length between transmitter and receiver
- Calculation of velocity, V = L / T (L – Path length, T-time)

UPV value km/sec. (V)	Concrete quality
Greater than 4.00	Very good
Between 3.50 and 4.00	Good, but porous
Between 3.00 and 3.50	Poor
Between 2.50 and 3.00	Very poor
Between 2.00 and 2.50	Very poor and low integrity
Less than 2.00	No integrity, large voids suspected

Semi-destructive tests for strength estimation of concrete

- **Pull-off test:** The pull-off test is used to determine the tensile strength of concrete by application of the in-situ concrete by application of direct tensile force. The test is also used for measuring the bond of surface repairs. A circular steel probe is glued to the concrete with an epoxy resin. Before applying the adhesive, the concrete surface is roughened with sandpaper and then degreased with the help of suitable solvent. After the epoxy resin has cured sufficiently, the metal disk is pulled off from the concrete surface manually or mechanically. The tensile strength of the bond being greater, the concrete fails in tension. The tensile force required to cause failure is recorded from which the tensile strength is calculated on the basis of the disk diameter i.e., 50 mm, and this may be converted to the compressive strength using a calibration chart appropriate to the concrete.

Engineered demolition techniques for dilapidated structures:

- Hydraulic Rock Breakers
- Diamond sawing and Drilling
- Diamond wire sawing system
- Silent expansive chemicals
- Controlled Demolition
- Hydraulic Bursting / Splitting
- Thermal lancing
- Hydro demolition
- Robotic demolition


Thank you