UNIT 5
REPAIR, REHABILITATION
AND RETROFITTING OF
STRUCTURES

• P. Muthuraman
Syllabus

Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake – Demolition Techniques - Engineered demolition methods – Case studies.
Retrofit versus Repair and Rehabilitation

- Repair: actions improve functionality, as-built system, rectify the observed defects, non structural, if carried out on structural elements unlikely to enhance structural strength, doesn’t guarantee structural safety (especially to dynamic forces), involves patching cracks and falling plaster, fixing doors windows etc.
• **Rehabilitation**
  
  - Structural interventions to improve strength of buildings which deteriorated or damaged
  - intended to regain its original strength of the member by strengthen or replace the structural systems, removal or rebuilding the damaged walls.
  - Grouting (injection of materials) and guniting (A cement gun used under a pressure of about 20 to 30 N/cm²) damaged concrete structures,
  - Underpinning, adaptation of vacant schools into apartments, warehouses into offices etc.,
Retrofit

- Retrofit specifically aims to enhance the structural capacities (stability and integrity) which are vulnerable or deficient
- Seismic rehabilitation, seismic upgradation And seismic strengthening – seismic retrofit
- Building need not to be damaged or deteriorated
- Intended to mitigate the effect of a future earthquake
- It includes the providing of additional parts to structures
Seismic Retrofitting

- A Seismic Retrofit provides existing structures with more resistance to seismic activity due to earthquakes.

- In buildings, this process typically includes strengthening weak connections found in roof to wall connections, continuity ties, shear walls and the roof diaphragm.
Reviewing initial considerations

Selection of the objective of retrofit
- Conventional objectives
- Performance based objectives

Obtaining information of the building
- Data collection
- Condition assessment

Seismic evaluation
- Preliminary evaluation
- Detailed evaluation

Decision to retrofit

No

Building adequate or, Building to be demolished

Yes

Selection and design of retrofit strategies
- Global retrofit strategies
- Local retrofit strategies

No

Verification of retrofit scheme

Acceptance

Yes

Construction
- Quality assurance and control

Maintenance and monitoring
Evaluation and Strengthening of Existing Buildings

- Collect information from an existing structure
- Assess whether info is dependable and penalize accordingly
- Identify for each member the damage level
- Decision based on number of elements at certain damage levels
- Finally, Conduct structural analysis done before and after retrofitting on structural model
  - Linear static analysis
  - Nonlinear static analysis (Pushover analysis)
  - Incremental pushover analysis
  - Time history analysis
Strengthening of Structural elements

- Factors affecting selection of strengthening method
  - Magnitude of strength increase
  - Effect of changes in relative member stiffness
  - Size of project
    - methods involving special materials and methods may be less cost-effective on small projects
  - Environmental conditions
    - methods using adhesives might be unsuitable for applications in high temperature environments
    - external steel methods may not be suitable in corrosive environments
• In-place concrete strength and substrate integrity
  – the effectiveness of methods relying on bond to the existing concrete can be significantly limited by low concrete strength
• Dimensional / clearance constraints
  – section enlargement might be limited by the degree to which the enlargement can encroach on surrounding clear space
• Accessibility
• Operational constraints
  – methods requiring longer construction time might be less desirable for applications in which building operations must be shut down during construction
• Availability of materials, equipment, and qualified contractors.
• Construction cost, maintenance costs, and life-cycle costs.
• Load testing to verify existing capacity or evaluate new techniques and materials
STRENGTHENING TECHNIQUES

• Section enlargement
• External plate bonding
• Post-Tensioning
• Ferrocement laminates
• Sprayed concrete
• FRP
Section enlargement (Jacketing)

- Jacketing
  - Adding R.C. jacket section
  - achieve the desired section properties and performance

- Advantages
  - Increasing of the load-carrying capacity
  - Increasing of the stiffness.

- Disadvantages
  - Increase in the concrete member size obtained after the jacket
  - The need to construct a new formwork.
Stages of section enlargement

- i. Temporary supports
- ii. Removal of the deteriorated concrete
- iii. Corrosion removal from the exposed reinforcement
- iv. Surfaces cleaning and preparation to ensure bonding with the repair material
- v. Replacement or addition of the supplementary reinforcement
- vi. Reinforcement protection (in some cases)
- vii. Formwork and applying of the repair material
Add Steel Bars

New Concrete

Additional Steel

New Concrete

Stirrups 8 mm @200 mm
External plate bonding

- Steel plates or steel flat bars are bonded to the structural elements
- Widely appear in strengthening of bridge structures.
- The bonding is ensured by:
  - the use of epoxy adhesives
  - additional fastening by means of dowels or bolts glued to the holes drilled in the concrete members.
- Disadvantages:
  - it can be applied only to the relatively sound structures.
• **Post-Tensioning**

• Effective in increasing the flexural and shear capacity

• Applied to reinforced and prestressed concrete members

• The post-tensioning forces are delivered by:
  - Standard pre-stressing tendons
  - High-strength steel rods

• Usually located outside the original section.

• The repair system supplements minimal additional load to the structure thus being an effective economical strengthening technique.
Internal Post-Tensioning

External Post-Tensioning
Stages of the post-tensioning strengthening

i. If there are existing spalls patching must be done, because this repairs must ensure that the pre-stressing forces are distributed uniformly across the section of the member

ii. The existing cracks must be repaired by means of epoxy injecting or other known methods

iii. The tendons are connected to the structure at anchor points, typically located at the ends of the member
• **Ferrocement laminates**

• Thin composite material made of cement mortar reinforced with wire meshes.

• The wire meshes are uniformly distributed in continuous layers with relatively small diameters.

• The Ferro cement is used to replace the damaged concrete.

• Strengthening with Ferro cement improves:
  - cracking resistance
  - flexural stiffness
  - the ultimate loads compared to the original un-strengthened element.
Figure (3): Ferrocement strengthening technique by adding wired steel mesh to R.c. slab
Sprayed concrete (shotcrete)

- It is one of the oldest materials and the most common techniques of repairing and strengthening of reinforced concrete structures.

- Sprayed concrete has been used in that field for almost 90 years.

- There are two processes for applying sprayed concrete
  - dry mix sprayed concrete in which most of the mixing water is added at the nozzle
  - wet mix sprayed concrete in which the ingredients, including water, are mixed before introduction into the delivery hose.
• Both dry mix and wet mix sprayed concrete are used in concrete repair / strengthening work, but the use of dry mix sprayed concrete is more common.
Shotcreting

Dry injection method
• Wet injection method
Strengthening using Fibre Reinforced Polymer (FRP)

- Lightweight
  - Easy to install

- High Strength
  - 5x steel

- Corrosion resistant
  - Durable structures

- Highly versatile
  - Suit any project
- Plastic and polymer materials that are reinforced with structural fiber such as
  - fiberglass (GFRP)
  - carbon fiber (CFRP)
  - aramid fiber.

- **Common methods**
  - Externally bonded FRP (EBR).
    - FRP plate bonding.
    - FRP Confining or jacketing
  - Sprayed fiber reinforced polymers
Stress-strain diagrams (MBT Australia)

N/mm²

Concrete:
- $\sigma_c$ vs $\varepsilon_c$
- $f_{fu}$ vs $\varepsilon_f$
- $f_y$ vs $\varepsilon_y$

FRP:
- $\sigma$ vs $\varepsilon$
- $f_{fu}$ vs $\varepsilon_{fu}$

Steel:
- $\sigma$ vs $\varepsilon$
- $f_y$ vs $\varepsilon_y$
- $\varepsilon_{fu}$ vs $\varepsilon_{su}$
### Typical densities of FRP materials, kg/m³ (ACI Committee 440, 2002)

<table>
<thead>
<tr>
<th>Material</th>
<th>Steel</th>
<th>GFRP</th>
<th>CFRP</th>
<th>AFRP</th>
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<tbody>
<tr>
<td></td>
<td>7,900</td>
<td>1,200 – 2,100</td>
<td>1,500 – 1,600</td>
<td>1,200 – 1,500</td>
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</tbody>
</table>

### Typical properties of prefabricated FRP strips and comparison with steel (FIB 2002)

<table>
<thead>
<tr>
<th>Material</th>
<th>Elastic modulus (GPa) - $E_r$</th>
<th>Tensile strength (MPa) - $f_r$</th>
<th>Ultimate tensile strain (%) - $\varepsilon_{fu}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabricated strips</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low modulus CFRP</td>
<td>170</td>
<td>2800</td>
<td>1.6</td>
</tr>
<tr>
<td>High modulus CFRP</td>
<td>300</td>
<td>1300</td>
<td>0.5</td>
</tr>
<tr>
<td>Mild steel</td>
<td>200</td>
<td>400</td>
<td>25 (Yield strain = 0.2 %)</td>
</tr>
<tr>
<td>E-glass fiber</td>
<td>2410</td>
<td>79.0</td>
<td>3.04</td>
</tr>
</tbody>
</table>
• Sprayed carbon or glass chopped fiber with vinyl ester resin upon concrete structures

Benefits of using vinyl ester resin:

• it takes shorter time to harden the resin than epoxy resin

• the mechanical properties of vinyl ester resin are the same as the one of epoxy resin
## Typical FRP strengthening applications

<table>
<thead>
<tr>
<th>Type</th>
<th>Application</th>
<th>Fibre Dir.</th>
<th>Schematic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural</td>
<td>Tension and/or side face</td>
<td>Along long. axis of beam</td>
<td><img src="image1" alt="Section" /></td>
</tr>
<tr>
<td></td>
<td>of beam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shear</td>
<td>Side face of beam (u-wrap)</td>
<td>Perpendicular to long. axis</td>
<td><img src="image2" alt="Section" /></td>
</tr>
<tr>
<td></td>
<td>of beam</td>
<td>of beam</td>
<td></td>
</tr>
<tr>
<td>Confinement</td>
<td>Around column</td>
<td>Circumferential</td>
<td><img src="image3" alt="Section" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Typical FRP strengthening applications

Flexural strengthening of slab

Shear strengthening and confinement of column
shear strengthening of beam-column joint

Flexural strengthening of beam

wrapping of concrete tank
Strengthening of concrete structures

- Foundations
- Slabs
- Walls
- Beams
- Columns
- Masonry walls
Strengthening the foundations

Piling

Shotcreting
Concrete casting
• Columns foundations need strengthening in the case of applying additional loads.

• Widening and strengthening of existing foundations may be carried out by constructing a concrete jacket to the existing footings.

• The new jacket should be properly anchored to the existing footing and column neck in order to guarantee proper transfer of loads.

• This can be accomplished by drilling holes into existing concrete of footing and epoxy grouting the longitudinal reinforcement of jacket.
Step #1: Excavating around the footing.

Step #2: Roughening the surface.

Step #3: Installing steel dowels in footing and column.

Step #4: Installing the new steel bars.

Step #5: Coating the surface with epoxy and pouring the concrete jacket.
Strengthening the foundations

Column strengthening by casting new foundation

Temporary supporting with steel columns

WeeGee-house, ESPOO
Strengthening of R.C. slabs

- Strengthening of reinforced concrete slab by removing the concrete cover and applying new bottom steel rods to flexural zones of slab to enhance its positive flexural capacity.
- Applying new top steel rods to flexural zones of cantilever slab to enhance its negative flexural capacity.
Adding new steel bars to RC slab using section enlargement technique. (a) from bottom, (b) from top

Ferrocement strengthening technique by adding wired steel mesh to R.C. slab
Strengthening a slab by increasing its depth from bottom

Step #1: Supporting the slab, removing the concrete cover, cleaning the steel bars and casting them with epoxy.

Step #2: Installing vertical and horizontal dowels at 25 cm spacing in each direction.

Step #3: Installing the new steel mesh.

Step #4: Coating the surface with epoxy.

Step #5: Pouring the required new layer of concrete.
- Strengthening a slab by increasing its depth from the top

Step #1: Removing the concrete cover and roughening the surface.

Step #2: Installing steel dowels at 25-50 cm spacing in both directions.

Step #3: Installing the new mesh and fastening it with the dowels.

Step #4: Pouring the required new layer of concrete.
Strengthening of R. C. slabs

- Strengthening the slab with stressing method
- Increasing punching shear capacity of the slab
  - Bolting through the slab
  - Strengthening hollow-core slabs
Strengthening the R.C. walls

- The dimensions of the wall and its reinforcement are increased by the following steps:
  
  1. Roughing the total area of the concrete surface.
  2. Installing steel connectors for the whole surface at 25-30 cm spaces in both directions.
  3. Installing steel connectors into the wall footings, with the same number and diameter of the main vertical steel bars, using an epoxy material.
  4. Installing the steel mesh and fasten it by steel wires to the steel connectors.
5. Coating the surface of the wall with an appropriate epoxy material.

6. Pouring the concrete jacket using low shrinkage concrete before drying of the epoxy material.
Strengthening of R. C. beams

- Reinforced concrete beams need strengthening when the existing steel reinforcement or cross section in the beam is unsafe or insufficient

- or

- when the loads applied to the beam are increased due to the reasons mentioned before
Strengthening of RC beam by using steel plates

Strengthening procedure of RC beam by adding new steel bars to the bottom of the beam
Strengthening of R. C. 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 • Tensile and/or shear capacity is to be increased by gluing steel sheets / carbon fiber reinforced laminates into a lower and/or side surface of the beam
- Reinforced concrete beam is to be strengthened by adding new steel bars.
Strengthening of R. C. beams

- **ADDING STEEL PLATES TO THE BEAM**

  1. Roughing and cleaning the concrete surfaces where the plates will be attached.

  2. Coating the concrete surfaces with a bonding epoxy material.


  4. Putting a layer of epoxy mortar on top of the plates with a 5mm thickness.

  5. Attaching the steel plates to the concrete using bolts.
Step#1: Cleaning and roughening the concrete surface.

Step#2: Coating the surface with epoxy.

Step#3: Fastening the steel plates using epoxy and bolts.
- Concrete beam is to be substituted with steel beam
- Steel profile is to be fixed into a concrete beam
- Steel profile is to be wedged below the beam
Strengthening a beam, slab and column.

Strengthening a beam and Slab.

Jacketing a beam by increasing bars and cross section.

Strengthening by steel plates.
Strengthening of R. C. beams

- Post-tension by external tendons
Share and Flexural Strengthening of Beam Using FRP
Strengthening of R. C. columns

• Strengthening of reinforced concrete columns:
  – Load increasing due to the increasing in floors number
  – Load increasing due to design mistakes
  – Compressive strength of concrete is not according to the code requirements
  – Percent or type of reinforcement is not according to the code requirements
  – Column inclination is more than allowable
  – Foundation settlement is more than allowable.
The concrete column after strengthening process

Installation of new steel cage around concrete column during strengthening process using RC jacketing.
Strengthening of R. C. columns

- Entirely or partly jacketing
- Strengthening the column with the steel form
- Increasing cross sectional surface with steel profiles
- Substituting the concrete column with the steel column
Rehabilitation Using Distributed Sacrificial Anode CP System

Memorial Bridge
Daytona Beach, Florida
181 Pile Jackets
Strengthening of masonry walls

Strengthening of Masonry Walls by Application of Single and Double sided reinforced concrete (RC) jackets
Strengthening of Masonry Walls using FRP Structural Repointing; (a) Grinding of masonry joints, (b) Masking of masonry to avoid staining, (c) Application of epoxy based paste to masonry joint, (d) Installation of GFRP Rods
Demolition Techniques
Demolition Techniques

- **Necessity of demolition**
  - Old building for further period cannot be put in use
  - Structural changes required
  - Modernization – old building to new building
  - Development of city – expansion of buildings
  - Structural failure – repair work not possible
  - Expansion or extension of buildings
• Demolition is the dismantling, razing, destroying or wrecking any building or structure or any part of building by pre-planned and controlled methods.

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

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

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

• Methods of demolition depends upon
  - type of structure
  - height and surrounding structures.
STEPS BEFORE DEMOLITION

1. Surveying
2. Removal of hazardous materials
3. Preparation of plan
4. Safety measures
For demolition of a building, detailed survey and assessment of a building is necessary.

1. Building survey

- Drawing records
- Material survey
- Hazardous materials
- Photographs of a building to be demolished
- Surrounding buildings
- Building height, distance from nearby buildings
- Type of building
2. Structural survey

- Drawing records
- Special structure
- Behaviour of structure
- Structural support system
- Degree of deterioration
Removal of hazardous materials

Soil Contamination Material

Asbestos Containing Material
Preparation of plan:

- Plan showing the location of a building to be demolished.
- Building height, structural system
- Extent of damage to the building
- Existing structures and facilities in the vicinity
- Layout plan
- Proposed method of demolition
- Safety measures
- Proposed sequence of demolition steps
- Details of equipments used.
- Plan for handling and disposal of debris
- Proposed arrangements for site supervision
Safety measures

Training and Communication:

Demolition workers, including plant or equipment operators, shall go through proper job safety training and be informed of the potential hazards by attending training sessions as well as on-the-job training.
Equipment Maintenance:

All equipment shall be tested and examined before use. They shall be properly stored and maintained.

The equipment shall be inspected daily and results of the inspection shall be recorded accordingly.
Electrical Safety

A properly connected power source from a local electric utility supplier or a mobile electricity generator shall be utilized in demolition sites.

Fire

- All flammable goods shall be removed from site unless they are necessary for the works involved.
- Any remaining flammable goods shall be stored in proper storage facilities.
- All furniture, timber, doors, etc. shall be removed before any welding work is performed. Fire fighting appliances shall be provided and maintained in working conditions.
Demolition of the floor slabs shall begin at mid span and work towards the supporting beams.
Floor beams shall be demolished in the order of cantilevered beams, secondary beams and then main beams.

Wire and winch shall be used to secure the cross beam to other structural members.

The concrete is first broken away at both ends near its column supports to expose the reinforcement.

Reinforcement shall be then cut to partially drop the beam and the brought down with wire.
• Secure the column by wire and winch to existing structure.
• Pre-weakening at the bottom of column:
  1. Break away the concrete to expose the reinforcing bars.
  2. Cut the reinforcing bars at the exterior half of the column.
  3. Cutting shall be performed immediately prior to pulling.
• Pulling down the column in a controlled motion.
METHODS OF DEMOLITION

- A. Ball and crane
- B. Dismantling
- C. Hydraulic breaker
- D. Pressure bursting
- E. Explosives
FACTORS AFFECTING SELECTION OF DEMOLITION METHOD

- Type of structure
- Size of structure
- Available time period
- Location of structure
- Limitation of noise, dust and vibrations
- Skill of workers
- Safety
- Availability of equipment
- Adjacent structures
Demolition techniques

- Engineering demolition
  - Mechanical methods
  - Implosion technique
- Non Engineering demolition
  - Manual demolition
- Deconstruction technique
MECHANICAL METHODS

- Wrecking method
- Pusher arm technique
- Thermic lance technique
- Non explosive demolition
- Concrete sawing method
- Deliberate collapse method
- Pressure jetting method
- bursting
MANUAL DEMOLITION

It is suitable for demolition of small buildings.

Tools required for manual demolition

- Hammers
- Picks
- Wire cutters
- Welding cutters
- Hand driven hydraulic jacks
SEQUENCE OF DEMOLITION

- All cantilevers structures shall demolished first.
- Before demolishing roof, all water tanks and lift rooms shall be demolished.
- Demolition of floor slab shall begin at mid span and proceed towards the supporting beams.

The order of demolition of floor beams shall be as follows:

- Cantilever beam, Secondary beam & Primary beam
- Non loadbearing walls and partition walls shall be removed prior to demolition process.
- Columns and load bearing walls shall be demolished after removal of beams on top.
Ball and crane

- This is one of the oldest and most commonly used methods for building demolition. A crane uses a wrecking ball, weighing up to 6120 kg, which is either dropped onto or swung into the element to be demolished.

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

- Concrete members can be broken into small pieces, but secondary cutting of reinforcing may be necessary.
Wrecking ball at rest

Swinging the wrecking ball
JIB HEAD 3m ABOVE
BUILDING BEING DEMOLISHED

1/2 H MIN.

VERTICAL DROP METHOD
Advantages:

1) To demolish roofs and other horizontal spans.

2) The wrecking balls are still used when demolition may not be possible due to local environmental issues or asbestos/lead building content.

Disadvantages:

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

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

3) The breakup process can cause considerable dust, vibration and noise which may be objectionable.
Dismantling

- Selective or complete demolition of concrete structures is possible by cutting elements and then removing them with a crane.

- The cutting process may be by sawing, water jetting or thermal lance.

- Because the surface of the cut concrete is smooth and relatively regular, these methods have particular application when the objective is partial demolition, for instance in the creation of openings in walls and slabs.
Dismantling a beam

Water Jet cutting
Thermal Lance

Sawing method
Advantages of Dismantling method:

1) Dismantlement of building components, specifically for reuse, recycling, and waste management.

2) Reducing disposal costs where waste collection, hauling or disposal is supported by the tax base.

3) Building components that are dismantled will need to be stored in a secure, dry location.

Disadvantages of Dismantling method:

1) The amount of time and cost of labor are the main drawbacks.

2) Harvesting materials from a structure can take weeks, whereas demolition may be completed in roughly a day.
Pneumatic and hydraulic breaker

- A common piece of equipment used for demolishing bridge decks, foundations and pavements is a hydraulically or pneumatically operated, boom-mounted breaker.
- The advantages of a machine mounted breaker may include a telescoping boom for easy reach and, remote control operation and underwater demolition capabilities.
- Some of the smaller remote-controlled machines can be lifted through window openings and used inside a building to demolish floors and walls.
- Productivity can vary greatly depending on hammer size, type of concrete, amount of reinforcing and working conditions.
Pneumatic hammer

Hydraulic breaker
Advantages

1) The hydraulic breakers have tremendous power output also means they are the most power efficient, getting the most work out of the available energy.

2) A properly used and maintained hydraulic machine can last for a long time.

3) Pneumatic breakers are simpler tools with fewer moving parts, requiring less maintenance.

Disadvantages

1) They require power, fuel or battery for their work.

2) They tend to be the most expensive types.

3) They require an external power source.
Pressure bursting

- Pressure bursting can be used in cases where relatively quiet, dust-free, controlled demolition is preferred.
- Both mechanical and chemical pressure bursting split the concrete, either with a splitting machine operating on hydraulic pressure provided by a motor in the case of mechanical bursting, or through the insertion of an expansive slurry into a pre-determined pattern of boreholes in the case of chemical bursting.
- The split concrete is then easily removed, either by hand or by crane.
- Both methods work by applying lateral forces against the inside of holes drilled into the concrete.
Pressure bursting
Explosives

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

- Numerous small explosives, strategically placed within the structure, are used to catalyze the collapse. Nitroglycerine, dynamite, or other explosives are used to shatter reinforced concrete supports.
RDX-based explosive compounds expand at a very high rate of speed, up to 27,000 feet per second (8,230 meters per second)
For the demolition of concrete structures it is usual to drill holes at a predetermined angle into the concrete to be removed.

Implosion is the strategic placing of explosive material and timing of its detonation so that a structure collapses on itself in a matter of seconds, minimizing the physical damage to its immediate surroundings.

The technique weakens or removes critical supports so that the building can no longer withstand the force of gravity and falls under its own weight.
PLACEMENT OF EXPLOSIVES – CROSS SECTIONAL VIEW
How Building Implosions Work

Process of Implosion
Wrapping of holes:

The wrapping of holes is done to ensure that due to explosion of charges the debris does not fly in air.

For this purpose, the holes were covered with gunny bags and iron net after placement of explosive and detonators.
Ballasting:

- Ballasting of Charges / Explosives work are carried out in a controlled manner such that there will be a time gap of 1/100 second between two successive blasts.
- The trigger of charges is done in such a control manner so that the noise pollution and air pollution should be minimum.

Falling of structure:

- Once central support/column will be destroyed and adjoining columns will be weakened, due to its gravity the entire mass will come down on its footprints.
Case Studies
Watch: Authorities demolish 100-year-old bridge in Thane
Case Studies

1. Chennai moulivakkam building demolition

C:\CE6021 Repair & Rehabilitation of Structures\Unit 5\Moulicvakkam.mp4
C:\CE6021 Repair & Rehabilitation of Structures\Unit 5\Collapse.3gp
C:\CE6021 Repair & Rehabilitation of Structures\Unit 5\Building Demolition.mp4

Case Study website:
http://www.independentexplosives.com/case-studies-2/
Discussions ?
thank you