
Welcome
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Structural Audit & Non Destructive Testing of Bridges

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Pvt. Ltd.

Non Destructive Testing,
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Structural Restoration Consultants

Structural Audit of Bridges & Life Line Structures

The recent collapse of Savitri Bridge, highlights the need of conducting detail *Structural Audit* along with conducting various *Non- Destructive Tests* and subsequently carrying out *Retrofitting*.

Structural Audit of Bridges & Life Line Structures

It's not only Bridges, BUT all LIFELINE structures are Important

- ✓ **As per National Disaster Management Act – 2005 guidelines, it is necessary to carry out a detail Vulnerability assessment & Retrofitting of important *Lifeline* structures.**

- ✓ **It's very important that all lifeline structures like Bridges, Hospitals, Schools, Colleges, Water Tanks, ETP, Transmission towers, Electrical sub-stations & switch yards should stand and function ever during and after any calamities like Earthquakes, Floods, Hurricanes, Landslides etc.**

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Structural Audit of Bridges & Life Line Structures

- Increase in collapses of number of bridges / Structure.
- Only visual inspection is not sufficient
- Advance Non Destructive Testing need to be carried out

Inspection of Masonry Bridges

- In India we have very large number of Bridges constructed in Masonry, which have crossed a life span of @ 75 to 100 years

- The actual safety level of these Bridges is uncertain due to the rise in traffic demand and the material deterioration that have occurred since they have been built

Inspection of Masonry Bridges

Common distresses include -

- Stone deterioration,
- Mortar weathering,
- Cracking in the arch barrel and spandrel wall, and displaced stone units.
- Efflorescence at the underside of the arch barrel is an indication of insufficient drainage within the arch.

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Inspection of Concrete Bridges

- The average life span of bridges is about 70 to 100 years
- Many bridges have crossed life span of 100 years
- Majority of bridges currently in use were built after 1950.
- However, significant environmental damage requiring repair, which typically occurs before the average bridge reaches mid-life.

Inspection of Concrete Bridges

- Corrosion, cracking and other damages affect a bridge's load carrying capacity. Therefore, all of the elements that directly affect performance of the bridge including the footing, substructure , deck, and superstructure must be periodically inspected or monitored.
- Fatigue cracking and corrosion will become increasingly important considerations as we go beyond the 50 year life expectancy

Deterioration of Concrete Bridges – Potential Causes

- Chloride-induced corrosion of the reinforcing steel.
- Poor Quality Construction
  - Use of an excessive amount of water in the concrete mixture;
  - Improper concrete placement, finishing, or curing practices;
- Accidental damage from collision or fire; and
- Design practices that fail to properly consider drainage requirements, stresses due to live and dead loads, shrinkage, or expansion.

Challenges in Structural Audit & NDT of Bridges

- **It's wrong perception that all old Masonry & RCC Bridges are unsafe and all New RCC / Pre-stressed Bridge are safe**

- **The potential penalties for ineffective inspection of bridges can be very severe. Instances of major bridge collapse are rare, but the results are truly catastrophic.**

- **Current visual inspection techniques will not suffice.**

- **The life extension approach will require increased use of NDE in a coordinated effort to obtain reliability assurance for these structures.**

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Rebound Hammer Test

The rebound hammer method is used for Concrete, Mortar & Bricks for assessing –

- **Surface compressive strength**
- **Uniformity**
- **Quality**

Different Rebound Hammers along with Calibration Anvil

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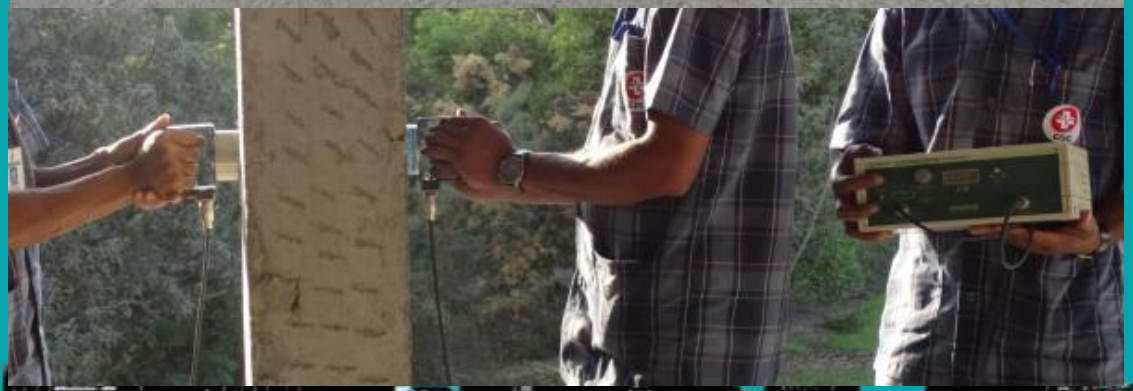
Ultrasonic Pulse Velocity Test

The ultrasonic pulse velocity method is used to assess

- The Quality / Compressive strength of concrete.
- The homogeneity of the concrete
- The presence of cracks, voids and other imperfections, depth of crack
- Changes in the structure of the concrete which may occur with time



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Core Test / Core Cutting

- Determining “In situ” compressive strength of structure.
- Small cores for chemical tests like pH, Carbonation, Sulphate & Chloride Content etc.
- Measuring Density, Water Absorption
- Identifying defect like Cracks, Voids, Honeycombing etc.
- Making weep holes in walls

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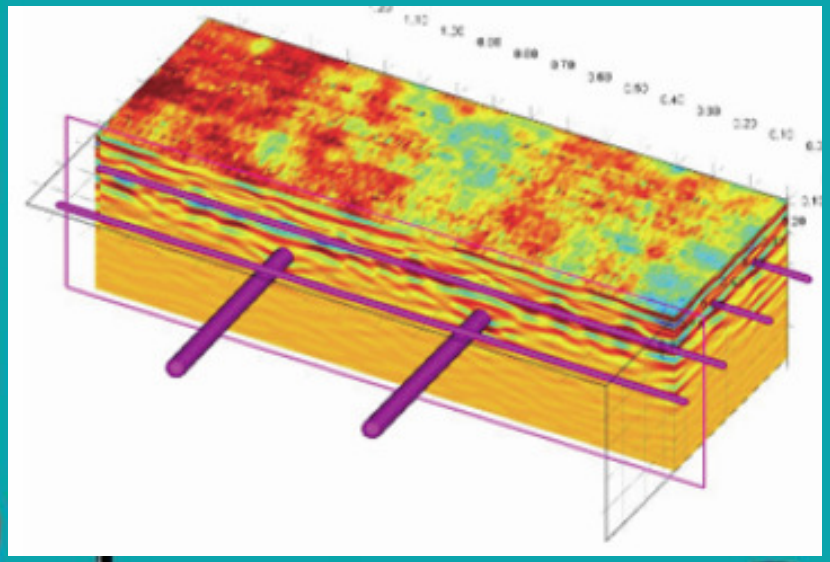
GPR – Ground Penetrating Radar

The state of Art Technology

- 3D imaging (Tomography) of shallow and deep rebars in concrete;
- Inspection of concrete for location of voids, internal defects, delamination and cracks
- Inspection of concrete thickness, integrity;
- 3D imaging of pre-tension and post-tension cables;
- Inspection and analysis of old structures and monuments;
- Inspection of walls and floors for the location of pipes, objects, caches, etc..



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Rebar Locator

- Detection of Reinforcing bars from concrete members, where RCC drawings are not available.
- Detecting bars for Core drilling, fixing anchors
- Detecting cover to the reinforcement along with carbonation test

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Half – Cell Potentiometer & Resistivity Test

Corrosion of embedded steel is probably the major cause of deterioration of concrete structures at the present time. Both of these tests are very useful to identify the corrosion.

Applications –

- **Determination of Corrosion Activity of the reinforcing steel**
- **Determination of likelihood of corrosion or corrosion risk**

Different Half-Cell Potentiometers

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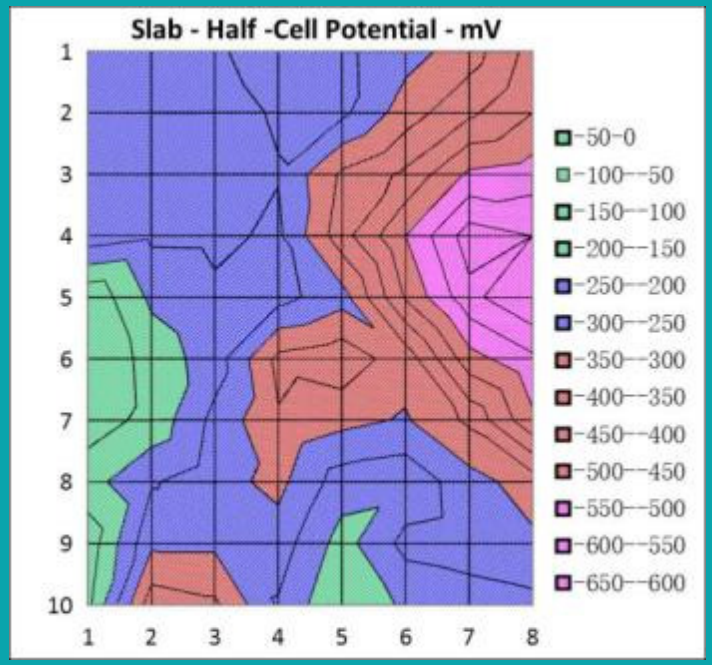
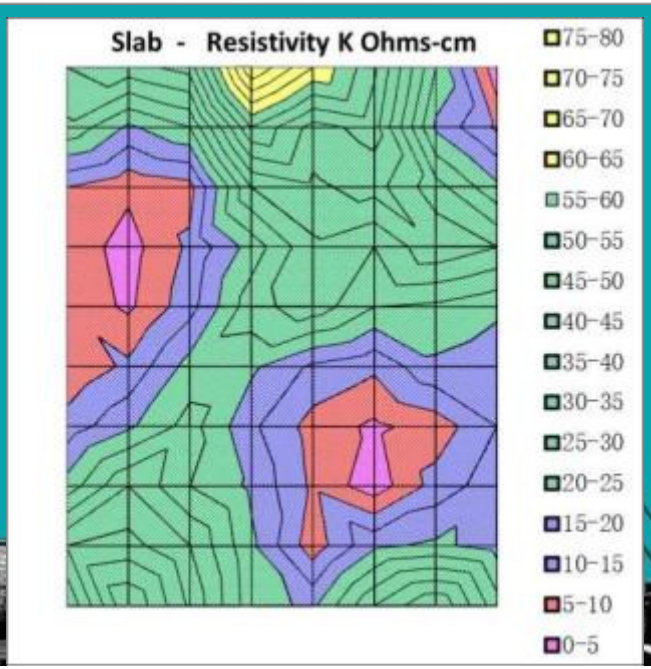
Half – Cell Potentiometer & Resistivity Test

Wenner 4 probe - Concrete Resistivity Meter





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Pile Integrity Test (Pulse Echo Method)

A pile integrity test is one of the advance methods for assessing the condition of piles or shafts. It is cost effective and not very time consuming.

Applications –

- Evaluation of Pile integrity and pile physical dimensions i.e. cross-sectional area, length, continuity, and consistency of the pile material

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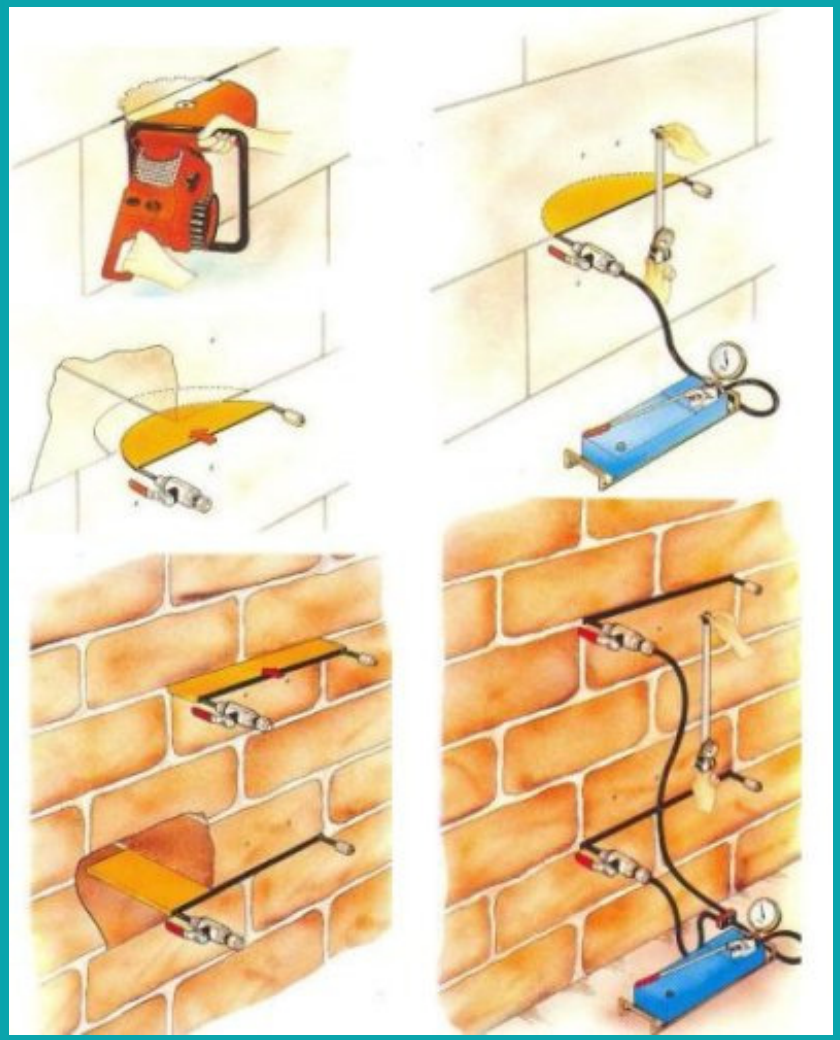
Flat Jack Test



This test method concerns the measurement of in-situ masonry deformability properties in existing masonry by use of thin, bladder-like flat jack devices that are installed in saw cut mortar joints in the masonry wall.

Applications –

- Determination of the average compressive stress in existing masonry
- Assessing the in-situ Compressive strength of masonry

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Vibration Measurement

Structures / buildings can get a vibration from sources such as Blast, Mining activity, Piling work, Machinery imbalance, Road / Rail / Metro traffic, Wind, Impact etc. Our Vibration Meter can measure Peak and Instantaneous Velocity, Acceleration and Displacement

Vibration Measurement for –

- Buildings / Structures
- Bridges,
- Chimney / Stacks
- Water Tanks
- Heritage Structures

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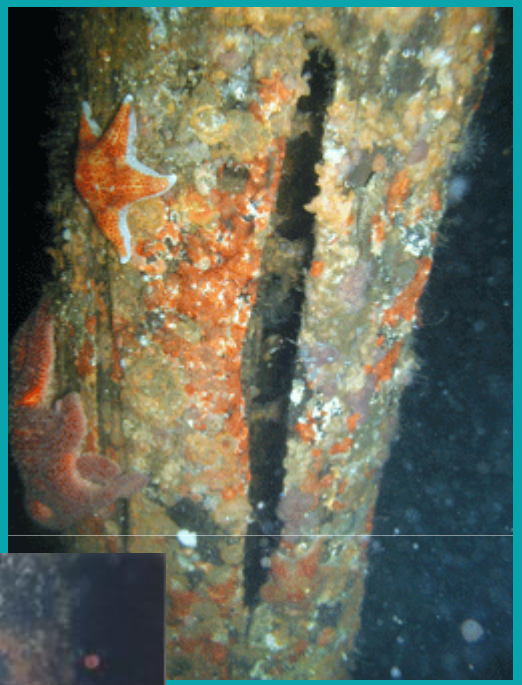
Underwater Investigation

We carry out underwater inspection of structures like –

- Dams
- Bridges
- Water Tanks
- Effluent & Water Treatment Plants
- Jetty
- Underwater Structures



Underwater Camera

Corrosion of Underwater Structures captured by Camera

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Drone Camera

Sophisticated Drone Camera for the inspection of structures like

- **Over Head Water Tanks**
- **Tall Structures**
- **Chimney**
- **Bridges**
- **Silo**

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Load Test

Many a times Load test is carried out on building & Bridge components when –

- **As a proof of Structural Adequacy.**
- **The strength of concrete is below the acceptable norms**
- **Structural Design data is not available.**
- **Load carrying capacity of the flexural member needs to be assessed.**
- **The members is to be subjected to a higher loads**
- **The members are noticed to have cracks, deflections**
- **The structure is damaged due to fire, earthquake, blast, corrosion etc.**
- **Change in use of structure.**
- **NDT or Core tests indicate a lower strength.**

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Other Non Destructive Testing - Techniques

Endoscopy / Bore scope - To inspect the in-accessible areas of structures , building components, Heritage structures, Pipes

Ultrasonic Thickness Gauge – For measurement of thickness of metal plates, pipes

Moisture Measurement – For measuring the moisture / dampness in timber, masonry, concrete, plaster

Infrared Thermal Camera – Used to identify the temperature gradient and spot temperatures, a very useful tool in structural audit.

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Case Studies - Bridge on NH - 4

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Case Studies - Bridge on NH - 4

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Case Studies - Bridge on NH - 4

Member	Site Concrete Strength
Columns	M – 25 to M - 35
Box Girder - Web	M – 20 to M - 30
Box Girder – Deck Slab	M – 15 to M - 25

Age of Bridge at the time of testing – 5 years

Case Studies – Cone failure

UPV is the best tool to identify the weak / hollow concrete

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Case Studies – Cube strength Doubtful

UPV + Core Test

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Case Studies – Cube strength Doubtful

UPV Comparison with accepted girder

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How many bridges under distress ?

- How many bridges are under distress ?
- Is the data available reliable ?
- Do we have a proper scientific method to identify the Bridges under distress
- At what frequency do we carry out such Audits
- Do we have sufficient funds for Inspections and Audits

Where it is Going Wrong

Workmanship

- Lot of developments in Const. Machinery, Materials, Const Techniques, Structural design BUT .....
- Poor Workmanship & Casual Attitude - one of the main Culprit for Bad quality work.

Over-stressing Cube strength

The parameters on which the CUBE strength of concrete depends –

- **Age – Blended cement concrete- slower strength development**
- **Size of cube**
- **Shape – Cube or cylinder V/s Shape of RCC members**
- **Mould material**
- **Texture of moulds**
- **Compaction – Layers, no. of blows, dia. of compaction rod.**
- **Curing temperature – 27 ^{0} C (+- 2 ^{0} C)**
- **Moisture conditions at the time of testing - SSD**
- **Type of compression testing machine – (Rocker & roller plate)**
- **Rate of loading – 140 Kg/Sqcm/ Min @ 310 KN/Min**

Does cube really fail in axial compression ?

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Where it is Going Wrong

- Is aggressive exposure condition, only to be blamed?
- Is high early strength, the only culprit?
- Or all these factors along with deteriorated workmanship need to be addressed.

Where it is Going Wrong – Our Observations

- ✓ Non Destructive Test results indicate very poor quality of the concrete, for structures constructed during last 30 years

- ✓ Older RCC structures constructed before 1970 with lower grade of concrete still show a good quality of concrete

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Where it is Going Wrong – Our Observations

NDT Results indicate

- ✓ About 15 to 30 % reduction in strength for more than 30 years old structures
- ✓ And more than 20 - 50 % reduction in concrete strength for structures of 25 to 30 years age
- ✓ **REASON - Very Poor workmanship / Quality Control & Speedy Construction**

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Some Suggestions for New Construction

- **Penalty / Bonus Clause not only for speed but also for Quality**
- ***Quality should be given higher preference over speed and economy***
- **It's high time, that we talk of 'Assured Quality with Guarantee'**
- **NDT to be carried out during construction and after every 10 years**

Cost of Quality – One of the survey indicate cost of doing things wrong is 12.5 % of the total project cost

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Let us Construct Healthy & Durable structures And Maintain them for their full lifespan

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Thank You

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