SCHEME :K

Name :______________________________
Roll No.:__________ Year : 20 ___ 20 __
Exam Seat No. :______________________

LABORATORY MANUAL FOR

MAINTENANCE AND REPAIRS OF STRUCTURES (316309)

CIVIL ENGINEERING GROUP

MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI
(Autonomous)(ISO21001:2018)(ISO/IEC27001:2013)

VISION:

To ensure that the Diploma Level Technical Education constantly matches the latest requirements of Technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

MISSION:

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the challenging technological & environmental challenges.

QUALITY POLICY:

We, at MSBTE are committed to offer the best-in-class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation, evaluation and monitoring system along with adequate faculty development programmes.

CORE VALUES:

MSBTE believes in the following:

- Skill development in line with industry requirements
- Industry readiness and improved employability of Diploma holders
- Synergistic relationship with industry
- Collective and Cooperative development of all stake holders
- Technological interventions in societal development
- Access to uniform quality technical education.

A Laboratory Manual

For

MAINTENANCE AND REPAIRS OF STRUCTURES

(316309)

SEMESER-VI

“K-SCHEME”

(CE/ CR/ CS/ LE)

Maharashtra State

Board of Technical Education, Mumbai.

(Autonomous) (ISO: 21001: 2018) (ISO/IEC 27001:2013)

Maharashtra State Board of Technical Education, Mumbai
(Autonomous) (ISO: 21001: 2018) (ISO/IEC 27001:2013)
4th Floor, Government Polytechnic Building, 49, Kherwadi,
Bandra (East), Mumbai – 400051,
(Printed On _____, 2024)

Maharashtra State
Board of Technical Education, Mumbai.

Certificate

This is to certify that Mr. / Ms.……………………………………………………Roll No………………………………..of Sixth semester of Diploma in …………………..………………………………………………………………………..of Institute,.……………………………………………………………..………………… ………………………………(Code:……………) has completed the term work satisfactorily in course **MAINTENANCE AND REPAIRS OF STRUCTURES (316309)** for the academic year 20…….. to 20……… as prescribed in the curriculum**.**

Place: …………… Enrollment No: …………………

Date: ……………. Exam. Seat No:…………………

Subject teacher **Head of the Department** **Principal**

Seal of
Institution

PREFACE

The primary focus of any engineering laboratory/field work in the technical education system is to develop the much-needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'I' Scheme curricula for engineering diploma programs with outcome-based education as the focus and accordingly, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a 'vehicle' to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accordingly, the 'K' scheme laboratory manual development team designed the practical's to focus on the outcomes, rather than the traditional age-old practice of conducting practical's to 'verify the theory' (which may become a byproduct along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the practical significance, Industry/Employer expected outcome(s), course outcomes and laboratory learning outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

In day-to-day working we come across different types of structures created for different purposes and functions. While designing the structures, analysis of forces and stresses is an important and prerequisite step. Correct analysis is possible only when one knows the types and effects of forces acting on the structures. This course provides the scope to understand Fundamental concepts of laws of mechanics and their applications to different engineering problems. This course is designed to provide basic understanding about the different types of forces, moments and their effects on structural elements, which will analyze different structural systems.

Although best possible care has been taken to check for errors (if any) in this laboratory manual, perfection may elude us as this is the first edition of this manual. Any errors and suggestions for improvement are solicited and highly welcome.

Program outcome (POs)

PO 1. Basic & Discipline specific knowledge: Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.

PO 2. Problem Analysis: Identify and analyze well defined engineering problems using codified standard methods.

PO 3. Design /Development Solutions: Design solutions for well-defined technical problems and assist with the design of systems components or processes to meet specified needs.

PO 4. Engineering tools experimentation and testing: Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

PO 5. Engineering practices for society sustainability and environment: Apply appropriate technology in context of society, sustainability, environment and ethical practices.

PO 6. Project Management: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

PO 7. Lifelong learning: Ability to analyze individual needs and engage in updating in context of technological changes.

List of Relevant Skills

The following industry identified competency through various teaching learning experiences. Repair and maintain different types of structures using appropriate materials and methods. To develop this competency, students should gain both practical experiences and relevant soft skills through teaching–learning activities. The outcome is that students will be able to demonstrate the following industry-relevant skills:

1. Identify the causes of structural damages and evaluate their extent.
2. Operate minor and major tools/equipment efficiently and safely to complete repair works.
3. Evaluate the strength and performance of different structural components in existing buildings.
4. Interpret results obtained from various structural tests and inspections.
5. Recommend suitable materials for repairing different types of defects/damages under varied site conditions.
6. Select and apply feasible repair and retrofitting technologies appropriate to the type and severity of damage.

Guidelines to teachers

Teachers shall discuss the following points with students before start of practical of the subjects.

1. Learning Overview: To develop better understanding of importance of the subject through intellectual skills and motor skills.
2. Know your laboratory work: To understand the layout of laboratory, specifications of equipment/instrument/materials, procedure, working in groups, planning time etc. also to know total amount of work to be done in laboratory.
3. For difficult practical's if required, teacher should provide the demonstration of the practical emphasizing of the skills which the student should achieve.
4. Teachers should give opportunity to students for hands-on after the demonstration.
5. Assess the skill achievement of the students and COs of each unit.
6. Teachers should give relevant information (including safety measures) to students prior to visit arranged for effective utilization of time and understanding.
7. Teachers shall ensure that required equipment are in working condition before start each experiment, also keep operating instruction manual available.
8. One or two questions ought to be added in each practical for different batches. For this teacher can maintain various practical related question banks for each course.
9. If some repetitive information like data sheet, use of software tools etc. has to be provided for effective attainment of practical outcomes, they can be incorporated in Appendix.
10. For effective implementation and attainment of practical outcomes, teacher ought to ensure that in the beginning itself of each practical, students must read through the complete write-up of that practical sheet.
11. During practical, ensure that each student gets chance and takes active part in taking observations/ readings and performing practical.

Note: Kindly do add specific guidelines for effective implementation of practical's depending upon your course, if needed.

Instructions to Students

1. For effective implementation and attainment of practical outcomes, in the beginning it self of each practical, student need to read through the complete write-up including the practical related questions and assessment scheme of that practical sheet.
2. Student must refer the data books, IS codes, safety norms, etc.
3. Student should not hesitate to ask any difficulties they face during the conduct of practicals.
4. Student should develop the habit of pear discussions/group discussion related to the experiment/exercise so that exchanges of knowledge /skills could take place.
5. Student shall attempt to develop related hands-on skills and gain confidence.
6. Students shall visit the nearby construction site, technical exhibitions, trade fair etc. even not included in the lab manual.
7. Students should develop the habit of not to depend totally on teachers but to develop self-learning techniques.
8. Student should develop habit to submit the practical exercise continuously and progressively on the scheduled dates and should get the assessment done.
9. It is necessary to take all types of precautionary measures by students during the visit.
10. Each student must follow the instructions given by the site engineer during the visit.
11. Special precautions must be taken for special type of work.
12. As far as possible, go through NPTEL, MOOC'S, SWAYAM website and register for the certificate courses.
13. Attach minimum four photographs of work done during site visit on separate blank page.

Note: Kindly do add specific instructions for students for effective implementation of practical depending upon your course, if needed.

Practical Course outcome matrix:

CO1 - Justify the need of repairs and maintenance for the given structure.
CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.
CO3 - Propose the relevant materials for undertaking the repair of given structures.
CO4 - Apply the relevant method of repair for the masonry work.
CO5 - Suggest the relevant method of repair to regain the strength of the given RCC component.

Pr. No.	Title of the Practical	Mapped Course Outcome				
		CO 01	CO 02	CO 03	CO 04	CO 05
01	Prepare the site visit report on pre-monsoon and post-monsoon maintenance strategies for given building.	√	----	----	----	----
02	*Prepare the detailed photographic report on damages observed during the visit to suggest the remedial measures.	----	√	----	----	----
03	*Prepare a photographic report on damage assessment and remedial measures of any one dam/bridge/industrial building.	----	√	----	----	----
04	*Determine the compressive strength of beam, column or slab of damaged or undamaged structure using Rebound Hammer at minimum 6 locations.	----	√	----	----	----
05	Determine the compressive strength of beam, column or slab using Ultrasonic Pulse Velocity test at minimum 3 locations.	----	√	----	----	----
06	Determine the dimensions and location of reinforcing bars of beam, column or slab using Rebar locator.	----	√	----	----	----
07	Determine maximum chloride content in beam, column or slab in percent by weight of cement using Rapid Chloride Test. (Use cube if coring is not possible.)	----	√	----	----	----
08	Determine the depth of carbonation of beam, column or slab using phenolphthalein indicator.	----	√	----	----	----
09	Determine the moisture content of beam, column or slab using Digital Moisture Meter.	----	√	----	----	----
10	Determine the corrosion extent of reinforcing bar of beam, column or slab using Half-cell Potentiometer.	----	√	----	----	----
11	Determine the extent of efflorescence at minimum 3 locations in given damaged or undamaged masonry or concrete structure.	----	√	----	----	----
12	*Prepare the structural audit report mentioning budget estimation, task force, equipment's and methodology for the given damaged structure.	----	√	----	----	----
13	*Prepare the check list of required materials with current market rates required for repair of the given damaged load bearing or framed structure.	----	----	√	----	----
14	*Prepare the visit report on materials and techniques required for repairing of spalling/delamination of plaster by visit/demo video.	----	----	----	√	----
15	*Prepare the visit report on repairing of roof slab/sanitary unit using any one technique to remove leakage.	----	----	----	----	√

CONTENT PAGE

List of Practical's and Formative Assessment sheet.

12	*Prepare the structural audit report mentioning budget estimation, task force, equipment's and methodology for the given damaged structure.	81						
13	*Prepare the check list of required materials with current market rates required for repair of the given damaged load bearing or framed structure.	89						
14	*Prepare the visit report on materials and techniques required for repairing of spalling/delamination of plaster by visit/demo video.	97						
15	*Prepare the visit report on repairing of roof slab/sanitary unit using any one technique to remove leakage.	104						
Total marks:								

These marks are to be transferred in pro-forma published by MSBTE.

- '*' Marked Practical (LLOs) are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

Practical No: 01 **Prepare the site visit report on pre-monsoon and post-monsoon maintenance strategies for given building.**

I. Practical Significance:

The purpose of this site visit is to study and document the maintenance practices adopted before and after the monsoon season for the given building. Monsoon plays a significant role in deteriorating building components due to heavy rains, moisture ingress, and waterlogging. Timely preventive and corrective maintenance ensure durability, safety, and serviceability of the structure.

II. Industry/Employer expected outcome(s):

- Ability to inspect, analyze, and prepare a professional site visit report detailing pre-monsoon preventive measures and post-monsoon corrective maintenance strategies for buildings.

III. Course Level Learning Outcome (COs):

- CO1 - Justify the need of repairs and maintenance for the given structure.

IV. Laboratory Learning Outcome (LLO):

- LLO 1.1 - Draft the maintenance strategies for given building.

V. Relevant Affective Domain Related Outcome(s):

- Develop concern for the importance of preventive maintenance to reduce long-term structural damage.
- Realize professional and ethical responsibility in ensuring building safety and durability.
- Cultivate a positive attitude toward proactive maintenance rather than reactive repairs.
- Show sensitivity towards environmental factors (rainfall, drainage, dampness, vegetation) affecting building performance.
- Demonstrate commitment to preparing accurate, detailed, and well-documented site visit reports.
- Exhibit cooperation, teamwork, and respect during site visits and report preparation.
- Build confidence in suggesting suitable remedial measures and maintenance strategies.

VI. Relevant Theoretical Background:

Building maintenance is essential to ensure the safety, durability, and functionality of structures. In monsoon-prone regions, preventive and corrective strategies are particularly important, as heavy rainfall, high humidity, and strong winds can lead to seepage, dampness, corrosion, and structural deterioration. **Pre-monsoon maintenance** mainly focuses on preventive measures such as cleaning and repairing roofs and drainage systems, applying waterproofing treatments, sealing cracks and joints, and checking the condition of structural and electrical components. These actions help safeguard the building before the onset of rains. **Post-monsoon maintenance** involves corrective measures to address damage caused during the season. This includes treating dampness and fungal growth, repairing plaster and finishes, checking for reinforcement corrosion, settlement cracks, and ensuring service lines are safe and functional. Together, pre- and post-monsoon strategies reduce repair costs, extend building life, and maintain structural performance.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Camera Photographs	As per availability	1 no.
2.	Note Pad, Pencil etc.		1 no. each student

VIII. Precautions to be followed:

- Walk only on designated safe pathways.
- Avoid touching exposed wires or wet electrical equipment.
- Follow instructions of teachers/site supervisor at all times.

IX. Procedure:

1. **Pre-Visit Preparation**
   - Obtain permission from building/site authorities.
   - Brief students on objectives, safety precautions, and site rules.
   - Carry necessary safety gear (helmet, safety shoes, gloves, and mask).
   - Collect site layout plans or previous maintenance records if available.
2. **On-Site Activities**
   - Assemble at the site and attend safety briefing by site supervisor.
   - Observe the building components such as roof, terrace, walls, drainage, electrical fittings, and foundation areas.
   - Record observations related to pre-monsoon preventive measures (e.g., waterproofing, drainage cleaning).
   - Identify post-monsoon issues (e.g., seepage, dampness, cracks, corrosion, and fungal growth).
   - Interact with site engineers/workers for practical insights into maintenance strategies.
   - Take photographs and notes for documentation.
3. **Post-Visit Activities**
   - Compile observations in a structured format (roof, walls, drainage, and foundation, electrical).
   - Analyse the effectiveness of pre- and post-monsoon maintenance measures.
   - Discuss findings with teachers and group members.
   - Prepare the final report including objectives, observations, analysis, and recommendations.

X. Observations:

Follow the format as given below and record the visual observation made during the visit. In Similar, a group of 20 students can visit and collect information and formats. Based on the above students have to prepare the report accordingly.

a. Name of the Building: …………………………………………………………..

b. Address of the building: …………………………………………………………

c. Date and time of visit: …………………………………………………………...

d. Type of building/structure: ………………………………………………….....

e. Year of construction: …………………………………………………………….

Sr. No.	**Building Component**	**Pre-Monsoon Condition / Measures**	**Post-Monsoon Condition / Issues**

(Note: Roof / Terrace, External Walls, Drainage System these are the suggestive building component for observations, students may write relevant points as per the visual observation along with the photograph capture during the visit.)

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. List the common pre-monsoon maintenance activities carried out for a building.
2. State two major problems generally observed in buildings after the monsoon season.
3. Explain the importance of waterproofing before the monsoon.
4. Enumerate the safety precautions to be followed during a site visit.
5. Differentiate between pre-monsoon and post-monsoon maintenance strategies.

<u>Space for Answer</u>

XIV. References / Suggestions for further Reading:

- IS 3067:1988 – Code of Practice for General Building Maintenance.
- IS 2395 (Part 1 and 2):1994 – Code of Practice for Painting Concrete, Masonry, and Plaster Surfaces
- IS 1742:1983 – Code of Practice for Building Drainage
- IS 6494:1988 – Code of Practice for Waterproofing of Basements
- NBC 2016 (Part 2, Part 4, and Part 8) – National Building Code of India

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Participation and discipline during site visit (safety, punctuality, attentiveness)	20%
2.	Observation skills and data collection (noting damages, conditions, checklists)	20%
3.	Teamwork and collaboration in preparing notes/checklists	20%
B.	**Product Related (10 marks)**	**40%**
4.	Quality of site visit report (clarity, systematic arrangement, use of photos/diagrams)	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 02 **Prepare the detailed photographic report on damages observed during the visit to suggest the remedial measures.**

I. Practical Significance:

Preparing a detailed photographic report during the site visit helps students to identify common building damages, understand their causes, and suggest suitable remedial measures. It promotes evidence-based reporting, improves analytical and decision-making skills, and bridges theoretical knowledge with real-life maintenance practices.

II. Industry/Employer expected outcome(s):

Students will be able to systematically observe and document building damages, analyze their causes, and recommend appropriate remedial measures. They will also develop practical reporting, teamwork, safety awareness, and problem-solving skills relevant to building maintenance and repair practices.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 2.1 - Identify the damages and relevant remedial strategies of an existing building.

V. Relevant Affective Domain Related Outcome(s):

- Demonstrate responsibility and punctuality during site visits.
- Value safety norms and follow precautions at all times.
- Show respect and cooperation while working in teams.
- Maintain honesty and integrity in recording observations.
- Exhibit discipline in completing tasks and preparing reports.
- Commit to suggesting sustainable and practical remedial measures.

VI. Relevant Theoretical Background:

Every building undergoes wear and tears due to environmental factors, material aging, and usage conditions. Common damages such as cracks, dampness, corrosion, efflorescence, and leakage not only reduce the durability of the structure but also affect its safety and serviceability. A photographic report serves as a reliable tool to document these damages with visual evidence, making assessment more systematic and authentic. By linking observed damages with probable causes, students can apply theoretical knowledge of construction materials, structural behavior, and repair techniques to recommend suitable remedial measures. This process bridges classroom learning with real-life building maintenance practices.

VII. Required resources/equipment:

S.N.	Resource required	Particulars	Quantity
1.	Camera Photographs	As per availability	1 no.
2.	Note Pad, Pencil etc.		1 no. each student

VIII. Precautions to be followed:

- Wear proper Personal Protective Equipment (PPE) such as helmet, safety shoes, and gloves during site visit.
- Follow the instructions of site in-charge/teacher at all times.
- Avoid entering restricted or unsafe areas of the building.
- Do not touch live electrical wires, panels, or wet surfaces.
- Maintain discipline and orderly movement while inspecting the site.
- Be careful while taking photographs—avoid blocking pathways or standing in unsafe positions.
- Ensure safe handling of tools/instruments used during observation.

IX. Procedure:

- Collect building drawings, previous maintenance records, and layout plans.
- Understand objectives of the site visit and identify areas to inspect.
- Ensure all students have necessary PPE (helmet, gloves, and shoes) and tools (camera, notebook).
- Attend safety briefing by the site supervisor.
- Divide tasks among team members for systematic inspection of roof, walls, foundation, drainage, electrical fittings, and interiors.
- Observe and identify visible damages: cracks, dampness, corrosion, seepage, settlement, peeling paint, etc.
- Take clear photographs of all observed damages.
- Label each photograph with location, component, and type of damage.
- Data Recording
- Maintain a checklist or table noting component, damage observed, probable cause, and severity.
- Record any additional observations provided by site engineers or maintenance staff.
- Analyze the causes of observed damages in relation to environmental factors, material quality, and structural conditions.
- Prioritize damages based on severity and potential risk.

X. Observations:

Follow the format as given below and record the visual observation made during the visit. In Similar, a group of 20 students can visit and collect information and formats. Based on the above students have to prepare the report accordingly.

a. Name of the Building: ……………………………………………………………..

b. Address of the building: ……………………………………………………………

c. Date and time of visit: ……………………………………………………………...

d. Type of building/structure: ……………………………………………………....

e. Year of construction: ……………………………………………………………….

Sr. No.	Building Component	Photograph	Observed Damage	Probable Cause	Suggested Remedial Measure

Sr. No.	Building Component	Photograph	Observed Damage	Probable Cause	Suggested Remedial Measure

Sr. No.	Building Component	Photograph	Observed Damage	Probable Cause	Suggested Remedial Measure

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. List the types of damages commonly observed in buildings during a site visit.
2. Explain the importance of documenting building damages with photographs.
3. Identify the probable causes of observed damages such as cracks, dampness, or corrosion.
4. Suggest suitable remedial measures for each type of damage observed.
5. Differentiate between structural and non-structural damages observed in the building.

<u>Space for Answer</u>

XIV. References / Suggestions for further Reading:

- IS 3067:1988 – Code of Practice for General Building Maintenance.
- IS 2395 (Part 1 and 2):1994 – Code of Practice for Painting Concrete, Masonry, and Plaster Surfaces
- NBC 2016 (Part 2, Part 4, and Part 8) – National Building Code of India

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Participation and discipline during site visit (safety, punctuality, attentiveness)	20%
2.	Observation skills and data collection (noting damages, conditions, checklists)	20%
3.	Teamwork and collaboration in preparing notes/checklists	20%
B.	**Product Related (10 marks)**	**40%**
4.	Quality of site visit report (clarity, systematic arrangement, use of photos/diagrams)	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 03 **Prepare a photographic report on damage assessment and remedial measures of any one dam/bridge/industrial building.**

I. Practical Significance:

Preparing a photographic report on damage assessment and remedial measures is practically significant as it provides reliable visual documentation of structural defects, supports accurate evaluation of damage, and guides in selecting suitable repair methods. It helps authorities in decision-making, serves as legal and safety evidence, and acts as a learning resource for engineers and students. Such reports also enable before-and-after comparisons for monitoring and ensure effective maintenance and safety of critical structures.

II. Industry/Employer expected outcome(s):

A photographic report that clearly documents structural damages and suggests practical remedial measures to ensure safety, durability, and effective maintenance of the dam/bridge/industrial building.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 3.1 Identify the damages and relevant remedial strategies of non-residential structure.

V. Relevant Affective Domain Related Outcome(s):

- Develop a sense of responsibility in assessing and documenting structural damages.
- Cultivate professional ethics and integrity in reporting findings.
- Build awareness of safety concerns related to damaged structures.
- Encourage teamwork and collaboration in preparing reports and suggesting measures.
- Foster a positive attitude towards preventive maintenance and sustainability of infrastructure.

VI. Relevant Theoretical Background:

a. **Structural Behaviour and Failure Mechanisms:** Structures like dams, bridges, and industrial buildings are subjected to various loads—dead load, live load, wind, seismic, and hydrostatic pressure. Over time, these can cause structural deterioration.

b. **Common Structural Damages:** Cracks: Can be due to shrinkage, settlement, overload, or thermal stresses.
   - **Corrosion:** Rusting of steel reinforcements reduces structural strength.
   - **Spalling and Leaks:** Surface layers breaking off or seepage in dams.

c. **Damage Assessment Techniques:**
   - **Visual Inspection:** Observing visible signs like cracks, deformations, leakage.
   - **Non-Destructive Testing (NDT):** Ultrasonic pulse velocity, rebound hammer, or infrared thermography to detect internal defects.

d. **Construction Material Behaviour:** Understanding concrete, steel, and masonry properties is crucial to predict failure and select suitable repairs.

e. **Remedial Measures and Repair Methods:**
   - **Grouting:** Filling cracks with cement or chemical grout.
   - **Jacketing:** Strengthening columns with reinforced concrete or steel.
   - **FRP Wrapping:** Using fiber-reinforced polymer sheets to improve tensile strength.

- **Waterproofing:** Preventing water ingress in dams or industrial buildings.

f. **Safety and Risk Management:** Evaluating structural safety, risk of collapse, and prioritizing remedial actions.

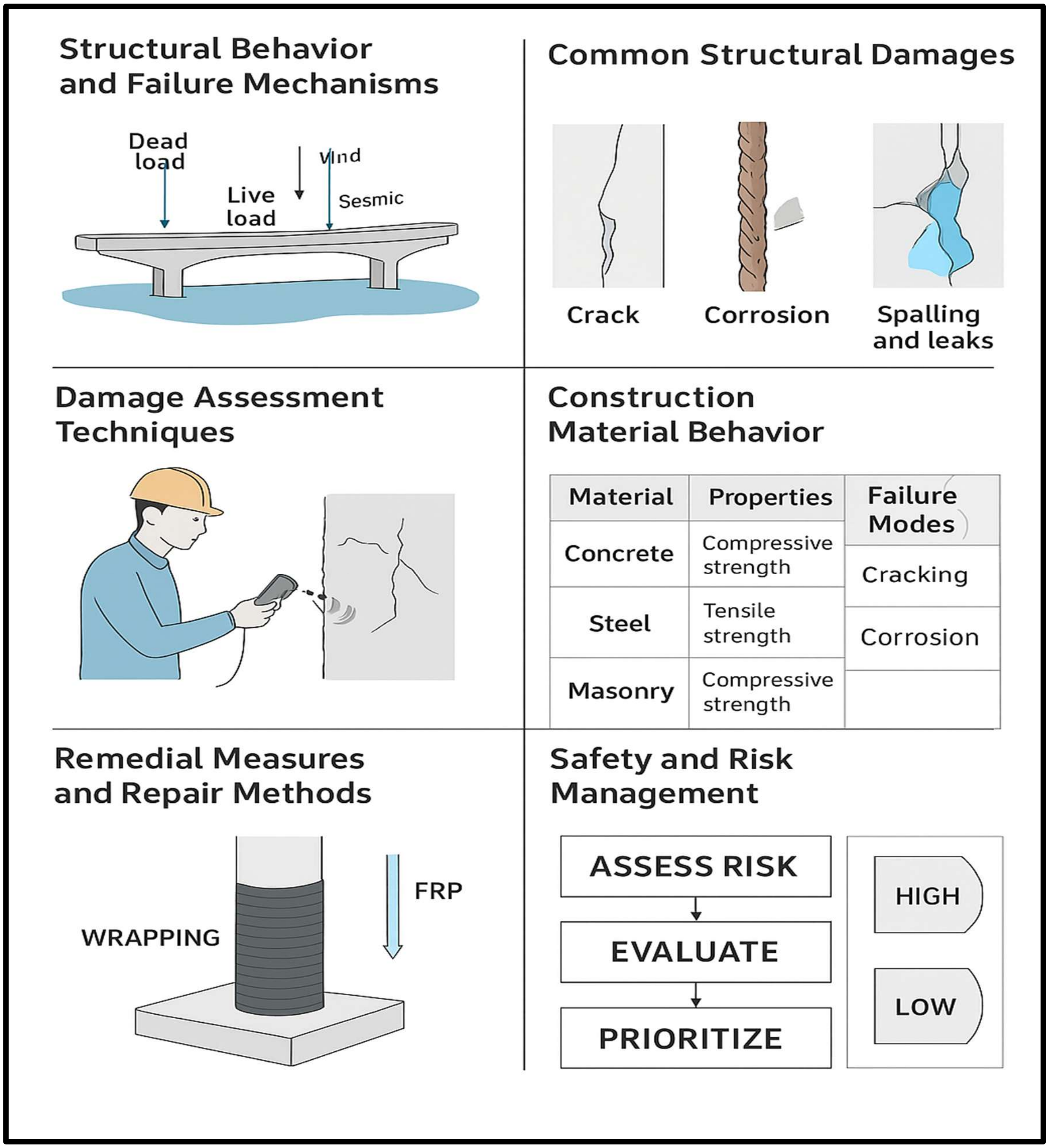


Figure No 1: Structural Behavior, Damage, and Repair Strategies

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1.	Microscope	Highly précised capable of magnifying crack width	1 No.	Per batch
2.	Measuring scale	15 or 30 cm in length	1 No.	Per batch
3.	Cleaning brush	Cleaning surface of the crack.	1 No.	Per batch

VIII. Precautions to be followed:

- Wear proper personal protective equipment (PPE) – helmet, gloves, safety shoes, reflective vest.
- Avoid standing under unstable structures or near edges; use harnesses when working at height.
- Follow site-specific safety protocols and warning signs.
- Ensure proper lighting and avoid blurring; use a tripod if needed.
- Capture multiple angles for each damage point and label photos immediately.
- Do not touch or disturb damaged areas; maintain a safe distance from fragile sections.
- Avoid placing heavy equipment on weak parts of the structure.
- Record observations immediately and cross-check measurements and locations.
- Maintain backup of all photographs and notes.
- Do not litter or damage the surrounding area; protect water bodies when inspecting dams or bridges.

IX. Procedure:

1. Visit in group a nearby non-residential building structure such as culvert, concrete road, bridge, Industrial construction, water tank GSR/ESR, jetty, spillways, KT weir, canal etc.
2. Carry out a visual inspection of identified structure.
3. Record the common damages observed as per the sample format provided in the observations.
4. Suggest suitable method for repair and prepare the check list.
5. Suggest detailed investigation and NDT if any those are essential.

X. Observation Table:

Follow the format as given below and record the visual observation made during the visit. In Similar, a group 20 students can visit and collect information and formats for other non-residential structures such as steel bridge, RCC ESR, industrial shades etc. can be prepared and according to visit of any one of the structures the visual inspection can be done.

a. Name of the Building: ……………………………………………………………………………..

b. Address of the building: ……………………………………………………………………………

c. Date and time of visit: ……………………………………………………………...............................

d. Type of building/structure: ………………………………………………………..............................

e. Year of construction: ………………………………………………………………………………..

Sr. No.	Component /Location	Type of Damage Observed	Severity (Minor/ Moderate /Severe)	Photograph	Possible Cause	Recommended Remedial Measure

Sr. No.	Component /Location	Type of Damage Observed	Severity (Minor/ Moderate /Severe)	Photograph	Possible Cause	Recommended Remedial Measure

Sr. No.	Component /Location	Type of Damage Observed	Severity (Minor/ Moderate /Severe)	Photograph	Possible Cause	Recommended Remedial Measure

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State four differences between residential and non-residential structures w.r.t. functional point of view.
2. State four differences between residential and non-residential structures w.r.t. loading point of view.
3. State four differences between residential and non-residential structures w.r.t. causes of damages.
4. Justify can we repair the non-residential structures with the same methods used for residential structures.
5. Comment on effect of hydrostatic pressure in case of repairs of cracks in water tanks.

<u>Space for Answer</u>

XIV. References / Suggestions for further Reading:

- IS 3067:1988 – Code of Practice for General Building Maintenance.
- IS 2395 (Part 1 and 2):1994 – Code of Practice for Painting Concrete, Masonry, and Plaster Surfaces.
- NBC 2016 (Part 2, Part 4, and Part 8) – National Building Code of India.

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Participation and discipline during site visit (safety, punctuality, attentiveness)	20%
2.	Observation skills and data collection (noting damages, conditions, checklists)	20%
3.	Teamwork and collaboration in preparing notes/checklists	20%
B.	**Product Related (10 marks)**	**40%**
4.	Quality of site visit report (clarity, systematic arrangement, use of photos/diagrams)	20%
5.	Timely submission and addressing identified COs (Completeness, accuracy of suggestions)	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 04 Determine the compressive strength of beam, column or slab of damaged or undamaged structure using Rebound Hammer at minimum 6 locations.

I. Practical Significance:

Using a rebound hammer to assess concrete strength has practical significance because it allows quick, on-site evaluation of the condition of structural elements like beams, columns, and slabs without causing any damage. By taking readings at a minimum of six locations, it becomes possible to identify variations in strength and detect weak or deteriorated zones that may not be visible externally. This method helps compare damaged and undamaged areas, assess the uniformity of concrete, and estimate probable compressive strength based on rebound numbers. The information obtained supports decisions related to repair, retrofitting, maintenance, or continued use of the structure. It also saves time and cost compared to destructive testing methods, making it a valuable tool for structural health assessment and safety planning.

II. Industry/Employer expected outcome(s):

Students will develop the ability to perform non-destructive testing using a Rebound Hammer to evaluate the compressive strength of concrete members at multiple locations and interpret the results for assessing the quality and integrity of existing structures.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 4.1 Determine the strength and homogeneity of given structural elements using NDT.

V. Relevant Affective Domain Related Outcome(s):

- Develops a responsible attitude toward structural safety and quality assessment.
- Encourages careful observation and ethical reporting of test findings.
- Builds confidence in using non-destructive testing methods for decision-making.
- Promotes discipline, accuracy, and accountability during field inspections.
- Fosters awareness of the importance of maintenance and structural health monitoring.

VI. Relevant Theoretical Background:

The Rebound Hammer Test (Schmidt Hammer Test) is a non-destructive method used to estimate the compressive strength of concrete based on the surface hardness. When the plunger of the rebound hammer impacts the concrete surface, the hammer rebounds — the rebound number (or rebound index) indicates the surface hardness, which correlates with compressive strength. The principle is that harder concrete surfaces produce higher rebound values. These values are then converted into estimated compressive strength using a calibration chart provided by the manufacturer. The test is governed by IS 13311 (Part 2): 1992, which specifies procedures, orientations, and correction factors. This method helps in assessing the uniformity, quality, and relative strength of concrete in existing structures, both damaged and undamaged, without causing any destruction to the structure.

Interpretation of Rebound Hammer Test Results: The correlation between compressive strength and rebound number can be done as per the graph in the figure given below. The strength of structure can be assessed from such correlation. In general, the rebound number increases as the strength increases.

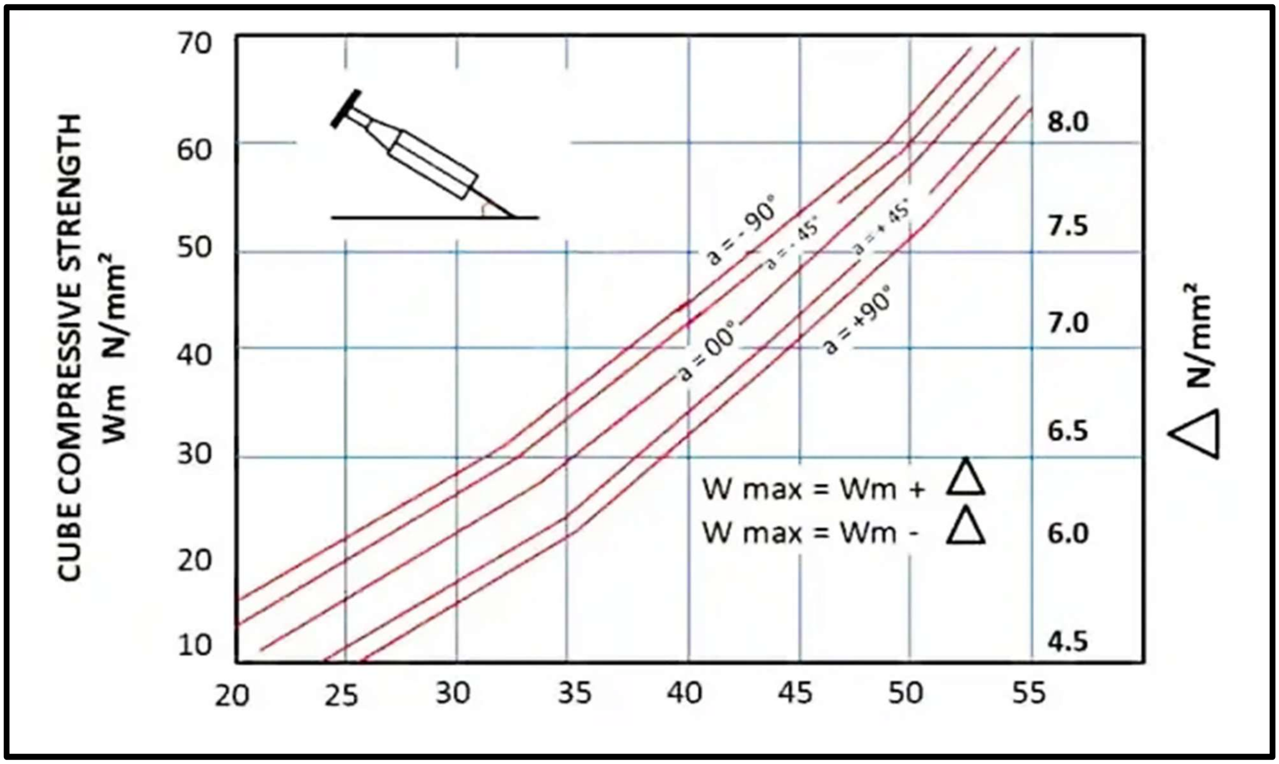


Figure No 2: Correlation between Rebound Number and Compressive Strength

Table.1: Quality of Concrete for different values of rebound number

Sr. No.	Average Rebound Number. (RN)	Overall Quality of Concrete.
1.	RN = 0	Delaminated
2.	RN < 20	Poor Concrete
3.	RN = 20 to 30	Fair
4.	RN = 30 to 40	Good Layer
5.	RN > 40	Very Good Hard Layer

VIII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1.	Rebound Hammer.	As per IS: 13311-Part-II-1992	1 No.	Per group of 5-7 students
2.	Grinding wheel or rough stone.	Sufficient for Cleaning loose material.	1 No.	Per batch
3.	Pencil or marker.	----	1 No.	Per group of 5-7 students

VIII. Precautions to be followed:

- Always use the hammer manufacturer's calibration curve and check calibration before testing.
- Do not test on very rough or loose surfaces; prepare and smooth small patches where required.
- Avoid testing too close to reinforcement or large aggregate particles — these skew readings.
- Maintain consistent hammer orientation and operator technique.
- Avoid tests on wet/damp surfaces; moisture lowers rebound. Record surface condition.
- For comparative studies, test similar elements in same manner (same orientation, same approximate area, same number of readings).
- If suspecting carbonation, perform phenolphthalein test or take small cores for lab confirmation before interpreting high surface hardness as high strength.

IX. Procedure:

A. Test preparation

1. Identify the element (beam / column / slab) and minimum 6 test locations spaced to represent the element (for larger members test more points). Avoid edges, large cracks, heavily honeycombed areas and reinforcement locations.
2. Mark test points clearly (number them 1 to 6 or more). Maintain at least 3–4 cm distance from edges and from each other if possible.
3. Ensure concrete surface at each point is smooth, clean and dry. Remove loose mortar, laitance or dust with a wire brush; if surface irregular, grind a small flat patch (~25–30 mm diameter). Allow to cool/dry if grinding heated the surface.

B. Test procedure (stepwise)

1. Check and note hammer calibration date and type. Note ambient conditions (temperature, wet/dry).
2. Hold the hammer perpendicular to the test surface (90°). Use the same orientation for all tests on that element. If surface is vertical (column/beam face), ensure consistent pressure and positioning.
3. Press the hammer firmly against the surface until the plunger is released; release plunger so hammers impact and rebound value is shown.
4. Take 2–3 successive readings at each marked location (without moving more than 5–10 mm from the initial point), discard obviously errant values, and record the reproducible reading. Typical practice: take three and use the median or average of the three for that point.
5. Repeat for all marked test points (minimum 6). Label and record each reading clearly on the data sheet along with point location and any visible defects (cracks, spalling).
6. After field readings, average the rebound numbers for the element and convert to compressive strength using the manufacturer's conversion chart or a validated correlation chart appropriate to the hammer type and concrete age. Do not use a generic chart — use the specific Schmidt hammer calibration curve supplied by the manufacturer or lab.

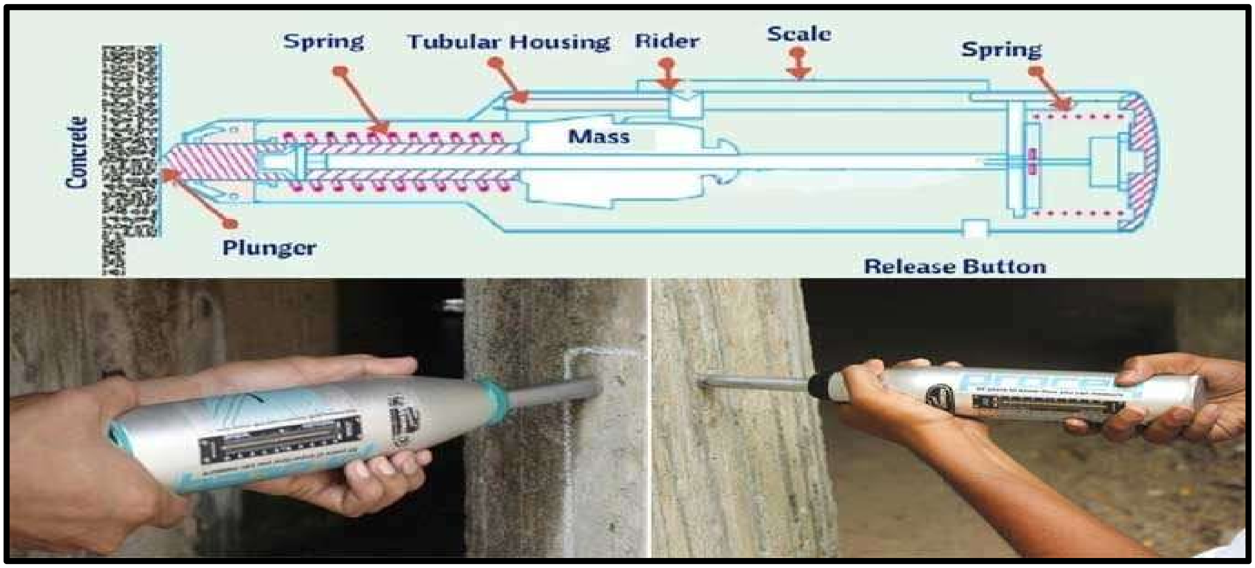


Figure No 3: (a) Components of Rebound Hammer (b) Use of Rebound Hammer
(Source: https://share.google/images/kMMInY2Oq45vIKxxJ)

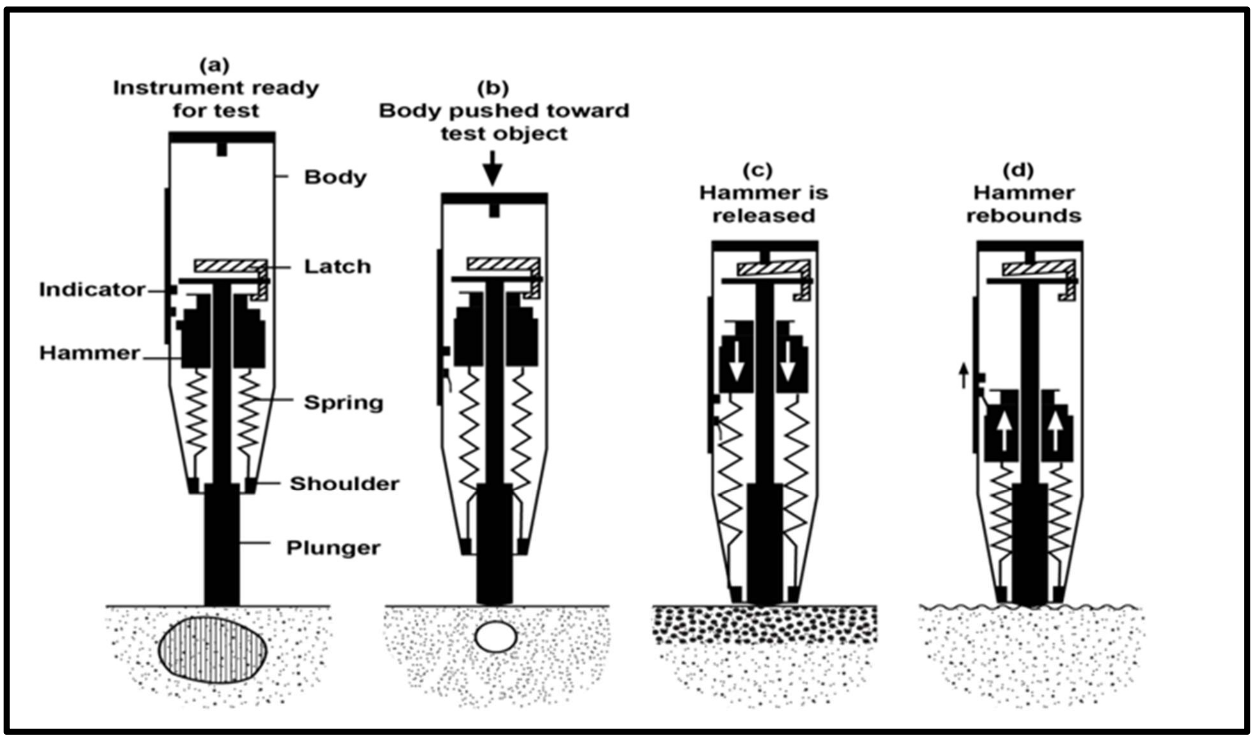


Figure No. 4: Stepwise Process of Rebound Hammer Test
(Source: https://share.google/images/ZCEaZsa4V7iycL63S)

X. Observation Table:

a. Location of Building: ……………………………………………………………

b. Number of floors in Building: ………………………………………………….

c. Condition of Building: ………………………………. (Damaged / Undamaged).

Sr. No.	Name of structural/building element *(any two)*	Position of Hammer	Rebound Number or Rebound Index					
			1	2	3	4	5	6
1	Beam							
2	Column							
3	Slab							

Calculations:

1. Average Rebound Number for building element: (beam, column, slab etc.).
   a) For Beam, N = …………………………………………… =......................... No.
   b) For Column, N = ………………………………………… = ... No.
   c) For Slab, N = …………………………………………… =.......................... No.
2. The compressive strength for building element (beam, column, slab etc.) from correlation graph.
   a) For Beam =.. N/mm^2.
   b) For Column =... N/mm^2.
   c) For Slab = ... N/mm^2.

Results:

1. The Rebound Number and Compressive strength of the tested Beam is found to be …………………… and ……………………N/mm^2 respectively.
2. The Rebound Number and Compressive strength of the tested Column is found to be…………………… and ………………… N/mm^2 respectively.
3. The Rebound Number and Compressive strength of the tested Slab is found to be …………………… and ………………… N/mm^2 respectively.

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State the significance of Rebound Number of concretes.
2. List out minimum two tools you have used for the preparation of concrete surface before going for rebound hammer test.
3. In which case, rebound number will be less i.e. in dry or wet condition of surface give reason.
4. In which case, rebound number will be less i.e. in horizontal position or inclined position of hammer give reason.
5. Give minimum four methods of Non-Destructive Testing for masonry structures.

<u>Space for Answer</u>

XIV. References / Suggestions for further Reading:

- Always use the hammer manufacturer's calibration curve and check calibration before testing.
- https://www.youtube.com/watch?reload=9&v=P_X5XLs4S2M&t=1s.
- IS 13311 (Part 2):1992 Methods of Non-Destructive Testing of Concrete – Part 2: Rebound Hammer.
- IS 456:2000 Code of Practice for Plain and Reinforced Concrete
- IS 516:1959 (Reaffirmed 2004) Method of Tests for Strength of Concrete
- IS 1199:1959 Methods of Sampling and Analysis of Concrete
- IS 8900:1978 Criteria for the Structural Safety of Buildings: General Principles

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Selection of test locations and surface preparation	20%
2.	Proper handling and operation of Rebound Hammer	20%
3.	Accuracy and completeness of observations (minimum 6 readings)	20%
B.	**Product Related (10 marks)**	**40%**
4.	Correct calculation and interpretation using calibration chart	20%
5.	Presentation of results, conclusion, and discussion	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 05 Determine the compressive strength of beam, column or slab using Ultrasonic Pulse Velocity test at minimum three locations.

I. Practical Significance:

The Ultrasonic Pulse Velocity (UPV) test is a non-destructive method used to evaluate the quality, uniformity, and integrity of concrete in structural elements like beams, columns, and slabs. By measuring the speed of ultrasonic pulses through concrete, this test helps in detecting cracks, voids, honeycombing, and deterioration without damaging the structure. It provides valuable information for assessing in-situ concrete quality, estimating compressive strength, and deciding maintenance, repair, or rehabilitation measures, which are essential in modern construction and structural health monitoring practices.

II. Industry/Employer expected outcome(s):

Students will be able to perform the Ultrasonic Pulse Velocity test at a minimum of three locations on beams, columns, or slabs to evaluate concrete quality and uniformity, detect internal defects, and interpret pulse velocity results as per IS 13311 (Part 1):1992 for structural assessment and maintenance decision-making.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 5.1 - Determine the strength and homogeneity of given structural elements using NDT.

V. Relevant Affective Domain Related Outcome(s):

- Develops a sense of responsibility and accuracy while performing non-destructive testing on structural elements.
- Encourages teamwork, safety awareness, and ethical behavior during field and laboratory testing.
- Promotes a professional attitude towards assessing and maintaining the quality and durability of concrete structures.

VI. Relevant Theoretical Background:

The Ultrasonic Pulse Velocity (UPV) test is a non-destructive testing (NDT) method used to assess the quality and integrity of concrete by measuring the time taken for ultrasonic pulses to travel through it. The pulse velocity depends on the density and elastic properties of the material — higher velocities indicate good quality, dense concrete, while lower velocities suggest the presence of cracks, voids, or deterioration. The test is conducted as per IS 13311 (Part 1): 1992, using transducers and a pulse generator/receiver placed on the concrete surface in direct, semi-direct, or indirect transmission modes. The results help in evaluating homogeneity, uniformity, and estimated strength of concrete in structural elements like beams, columns, and slabs.

Table 2: Pulse velocity ranges and corresponding concrete quality as per IS 13311 (Part 1): 1992

Sr. No.	Pulse Velocity (km/s)	Approximate Compressive Strength(S)	Concrete Quality	Remarks
1	> 4.5	S > 40 N/mm^2	Excellent	Dense, homogeneous concrete with minimal defects
2	3.5 – 4.5	S = 25 -40 N/mm^2	Good	Sound concrete, minor defects may be present
3	3.0 – 3.5	S = 10 - N/mm^2	Medium / Fair	Moderate quality concrete, some voids/cracks possible
4	2.0 – 3.0	S = 4 - N/mm^2	Poor	Significant defects, honeycombing, or deterioration
5	< 2.0	S < 4 N/mm^2	Very Poor	Severely deteriorated, highly porous, or cracked concrete

VII.Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Electrical pulse generator or Ultrasonic Pulse velocity Meter.	Confirming IS: 13311-Part-I 1992.	1 No.	Per batch.
2	Transducer	Piezoelectric and magneto astrictive type; frequency Lange of 50 kHz to 60 kHz.	1 Pair.	Per batch.
3	Amplifier	Confirming IS:13311-Part-I- 1992.	1 No.	Per batch.
4	Electronic timing device.	Accuracy of +/-1 percent over a range of 20 microseconds to 10 milliseconds.	1 No.	Per batch.
5	Acoustical coupling material.	Petroleum jelly, grease, liquid Soap and kaolin glycerol paste.	Sufficient Quantity	Per batch.

VIII. Precautions to be followed:

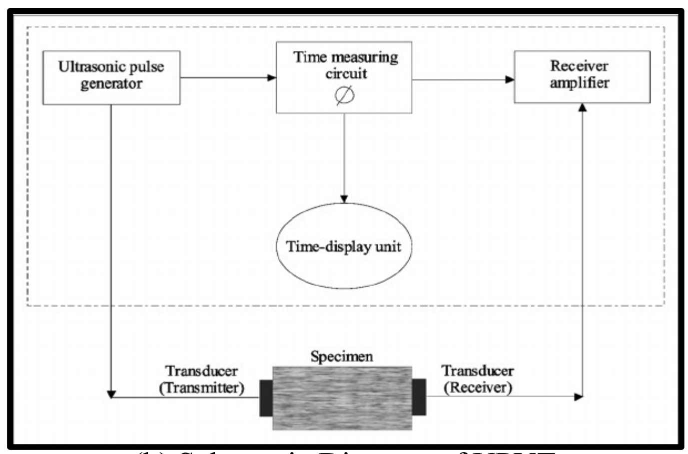
- Ensure the surface of concrete is clean, smooth, and free from loose particles, dust, or oil before placing the transducers.
- Maintain proper contact between the transducers and the concrete surface by using suitable couplant (e.g., grease, petroleum jelly).
- The transducer faces should be held firmly and perpendicular to the surface to avoid signal loss or scattering.
- Avoid testing on areas having visible cracks, voids, or reinforcement exposure, as they may give false readings.
- The instrument calibration should be checked before and after the test to ensure accuracy.
- Ensure the same distance between transducers at all test points for consistent comparison.

- Temperature and moisture conditions of the concrete should be noted, as they influence pulse velocity results.
- Do not apply excessive pressure on the transducers; gentle and uniform contact is sufficient.
- Avoid electrical or mechanical disturbances during measurement to prevent signal interference.
- Record all readings carefully and systematically at each of the minimum three locations for accurate analysis.

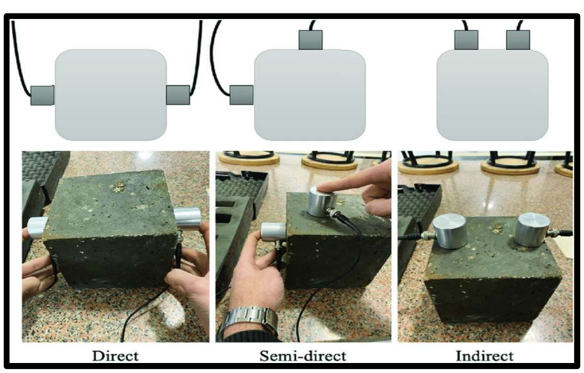
IX. Procedure:

1. Identify the element (beam, column, or slab) and select minimum 3 test locations representing the element.
2. Clean the concrete surface and mark test points.
3. Apply couplant on the contact surfaces of transducers.
4. Place the transducers in direct, semi-direct, or indirect mode as suitable:
    - Direct: Transducers on opposite faces (preferred)
    - Semi-direct: Adjacent faces
    - Indirect: Same face
5. Generate the ultrasonic pulse and record time of travel (t).
6. Measure the distance (L) between transducers.
7. Calculate Pulse Velocity (V) = L / t in km/s.
8. Repeat for all 3 or more locations, and record observations.
9. Compare results with the concrete quality table and interpret findings.
10. Estimate relative compressive strength if calibration correlation is available.

(a) Ultrasonic Pulse Velocity Meter with Probes
(Source:https://share.google/images/gnvuW9Wxh5IbDPDBB)



(b) Schematic Diagram of UPVT
(Source:https://share.google/images/5tI5TkLFPTaJL7U1x)



(c) Modes of Attaching Transducer Ends.
(Source:https://share.google/images/zb6r78n2rqd6aU1vZ)

Figure No.5: Showing Ultrasonic Pulse Velocity Meter

X. Observation Table:

a. Location of Building: ……………………………………………………………

b. Number of floors in Building………………………………………………….

c. Condition of Building: …………………………… (Damaged / Undamaged).

Sr. No.	Name of structural/ building element *(Any Two)*	Path Length (L) in mm	Transit Time of Waves (T) in sec.	Ultrasonic Pulse Velocity (V)=(L/T) (mm/sec)	Average Ultrasonic Pulse Velocity ($V_{avg.}$) in mm/sec.	Ultrasonic Pulse Velocity (V) in Km/sec.
01	Beam					
02	Column					
03	Slab					

Calculations:

1. Average Ultrasonic Pulse Velocity for building element:
   a) For Beam, $V_{avg.}$ =... mm/sec.
   b) For Column, $V_{avg.}$ = ...mm/sec.
   c) For Slab, $V_{avg.}$ =... mm/sec.

2. Ultrasonic Pulse Velocity for building element:
   a) For Beam, V = ... Km/sec.
   b) For Column, V =..Km/sec.
   c) For Slab, V =..Km/sec.

3. The approximate compressive strength for building element: from Table 1
   a) For Beam, $V_{avg.}$ =.. N/mm^2
   b) For Column, $V_{avg.}$ = ...N/mm^2
   c) For Slab, $V_{avg.}$ =.. N/mm^2

Results:

1. The average ultrasonic pulse velocity obtained for Beam is found to be ……………Km/sec. and its approximate compressive strength ………………. N/mm^2.
2. The average ultrasonic pulse velocity obtained for Column is found to be ……………Km/sec. and its approximate compressive strength ………………. N/mm^2.
3. The average ultrasonic pulse velocity obtained for Slab is found to be……………Km/sec. and its approximate compressive strength ………………. N/mm^2.

XI. Interpretation of results:

XII. Conclusions:

XII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. Name the company and cost of the ultrasonic pulse velocity test apparatus used in this test.
2. State in which case, the pulse velocity will be more, (i) Direct transmission or cross probing (ii) Semi-direct transmission or lateral probing (iii) Indirect transmission or surface probing. Justify the answer.
3. State out of which type of concrete i.e. PCC or RCC of same grade, the pulse velocity will be more and justify your answer.
4. Compare the ultrasonic pulse velocity test with rebound hammer test (min. two points).
5. State the approximate time required to conduct the ultrasonic pulse velocity test on one building element.

<u>Space for Answer</u>

XIV. References / Suggestions for further Reading:

- The instrument calibration should be checked before and after the test to ensure accuracy.
- https://www.youtube.com/watch?v=sIUqqGSsPdc&t=10s
- IS 13311 (Part 1): 1992 — Method of Non-destructive Testing of Concrete
- IS 516:1959 — Methods of Test for Strength of Concrete (for core / cube testing)

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Understanding of theoretical background and test principle	20%
2.	Accuracy in performing the UPV test and taking readings	20%
3.	Correct calculation and interpretation of results	20%
B.	**Product Related (10 marks)**	**40%**
4.	Quality and completeness of observation table and report	20%
5.	Presentation of results, conclusion, and discussion	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 06 **Determine the dimensions and location of reinforcing bars of beam, column or slab using Rebar locator.**

I. Practical Significance:

The Rebar Locator test plays a vital role in assessing the internal reinforcement of concrete structures without causing any damage. It helps in accurately determining the position, spacing, cover depth, and approximate diameter of reinforcing bars in beams, columns, or slabs. This information is essential for verifying whether the reinforcement has been placed as per the design specifications and for ensuring the structural integrity of the element. The test is particularly useful before drilling, cutting, or retrofitting operations, as it prevents accidental damage to embedded steel bars. Moreover, by identifying the concrete cover, it assists in evaluating the durability and corrosion risk of reinforcement. Overall, the use of a Rebar Locator enhances safety, quality control, and effective maintenance of reinforced concrete structures.

II. Industry/Employer expected outcome(s):

Students learn to use a Rebar Locator to find the steel bars inside concrete. This helps in checking the quality and safety of structures. Employers expect them to handle the tool correctly, find the bars as per the plan, and report the results clearly.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 6.1 Identify the location of reinforcing bar of the given RCC element using Rebar Locator.

V. Relevant Affective Domain Related Outcome(s):

- Develops a sense of responsibility for ensuring safety and structural integrity during site testing.
- Promotes careful observation and accuracy in NDT operations.
- Encourages professional ethics in recording and interpreting test results.
- Fosters teamwork and communication while handling field instruments.
- Builds confidence in performing on-site inspection and documentation.

VI. Relevant Theoretical Background:

The Rebar Locator is a non-destructive testing instrument used to determine the position, depth, and spacing of reinforcing bars in reinforced concrete structures. It operates based on electromagnetic principles and is essential for quality control, inspection, and repair works.

1. **Construction of Rebar Locator:** A rebar locator mainly consists of three parts — a search head (probe), a display/control unit, and connecting cables.
    - The search head generates and detects magnetic fields over the concrete surface.
    - The display unit shows information such as bar location, depth of cover, and sometimes estimated bar diameter.
    - The system is portable and battery-operated, making it suitable for on-site use.

2. **Principle of Rebar Locator Test:** The working principle of the rebar locator is based on electromagnetic induction. When the search head moves over a concrete surface containing steel bars, the magnetic field changes due to the presence of metal. This change is detected by the sensor and converted into an electrical signal, which is displayed as the position and depth of the reinforcement bar on the screen.
3. **Factors Affecting the Test Results:**
   - **Concrete cover thickness:** Greater cover reduces signal strength and accuracy.
   - **Bar diameter and spacing:** Closely spaced or large-diameter bars may cause overlapping signals.
   - **Concrete quality and moisture content:** Variations can affect electromagnetic response.
   - **Presence of other metallic objects:** Nearby metals or embedded conduits can distort readings.
   - **Surface condition:** Rough or uneven surfaces may reduce contact and affect accuracy.

Figure No. 6: Rebar Locator with accessories
(Source: https://share.google/images/qlyyi5SNE51ogLS1R)

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Rebar Locator with accessories like spot probe, diameter probe, depth probe	LCD with backlight; Depth range 100-185 mm; Accuracy ± 2mm, ±5% for cover.	1 No.	Per batch
2	Measuring scale	Least Count 1 mm.	1 No.	Per batch
3	Marking pen/chalk	-----	1 No.	Per batch

VIII. Precautions to be followed:

- Ensure the instrument is properly calibrated before starting the test to obtain accurate readings.
- The surface of the concrete should be clean, smooth, and free from dust, paint, or loose particles.
- Avoid the presence of metallic objects (like nails, wires, or tools) near the testing area, as they can interfere with the readings.
- Mark the scanning area clearly to ensure systematic and complete coverage of the surface.
- Maintain steady contact between the probe and the concrete surface while scanning to prevent signal distortion.
- Do not use the equipment near strong electromagnetic sources or power lines, as they may affect the accuracy.
- Take multiple readings at each location to confirm consistency and reliability of data.
- Handle the equipment carefully and store it properly after use to avoid damage to the sensor and display unit.

IX. Procedure:

1. Take the Rebar Locator apparatus and calibrate it using the test block provided. Ensure that the depth and size of the reinforcement bar shown by the apparatus match the actual bar (measured with a scale).
2. Identify the test surface of the beam, column, or slab and mark the target points in a grid pattern using a marking pen or chalk.
3. Set up any necessary staging, ladder, or suspended platform to access the test surface safely.
4. Clean and smooth the test surface by removing dust, debris, and unwanted projections.
5. Connect the Rebar Locator with the path measuring device and spot probes, and move the probe in horizontal and vertical directions over the surface.
6. Mark the location of each bar when its position appears on the display. Record the distance of the bar from the surface as shown.
7. Attach the diameter probe to the Rebar Locator and align it parallel to the located bar.
8. Observe the four readings displayed on the screen and take the mean value as the bar diameter.
9. Attach the depth probe to the Rebar Locator and place it directly over the identified bar location**.**
10. Note the concrete cover depth after hearing the audio signal (beep)**.** The detected value is stored in the device memory.

X. Observation Table:

a) Name of the Building: ………………………………………………………………

b) Address of the site: ……………………………………………………………….

c) Date and time of visit: ………………………………………………………………

d) Type of building/structure: ………………………………………………………

e) Year of construction: ……………………………………………………………….

Sr. No.	**Name of structural element** (beam/column/slab)	**Observed particulars**						**Average diameter of Steel Bar (mm)**
		Location / Position of Steel Bar (mm)	**Cover of Steel Bar (mm)**	**Diameter of Steel Bar (mm)**				
1								
2								
3								
4								
5								
6								

Results:

1. The details of size and location of the ……….. (beam/column/slab) tested by rebar locator are as follows.
   a. Position of bar from surface = ... mm.
   b. Minimum cover of reinforcement bar = ... mm.
   c. Average diameter of reinforcement bar =....................mm.

2. The details of size and location of the ……….. (beam/column/slab) tested by rebar locator are as follows.
   a. Position of bar from surface =………………………mm.
   b. Minimum cover of reinforcement bar =……………mm.
   c. Average diameter of reinforcement bar =………… mm

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. List out various types of probes along with their applicability required in this test.
2. Write the name and cost of company of test apparatus used by you in this test.
3. State the accuracy of rebar locator used by you.
4. Is it possible to detect the status of reinforcement corrosion with this rebar locator? If not, give the name of alternative equipment to be used for the same.
5. State any four applications of the rebar locator test.

Space for Answer

XIV. References / Suggestions for further Reading:

- The instrument calibration should be checked before and after the test to ensure accuracy.
- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
- IS 11504:1985 – Criteria for Structural Design of Reinforced Concrete Natural Draught Cooling Towers.
- https://www.youtube.com/watch?v=W62Y9OImC84
- https://www.youtube.com/watch?v=lIpRwMAlJ9A

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Proper calibration of Rebar Locator.	20%
2.	Accuracy in locating reinforcement bars.	20%
3.	Correct handling and use of probes during measurement.	20%
B.	**Product Related (10 marks)**	**40%**
4.	Correct measurement of bar diameter.	20%
5.	Correct measurement of concrete cover depth and proper recording of observations.	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 07 Determine maximum chloride content in beam, column or slab in percent by weight of cement using Rapid Chloride Test. (Use cube if coring is not possible).

I. Practical Significance:

Determining the maximum chloride content in reinforced concrete members using the Rapid Chloride Test is crucial for assessing the durability and service life of structures. Chloride ions, often present due to de-icing salts, seawater exposure, or contaminated aggregates, can penetrate concrete and initiate corrosion of embedded steel reinforcement, leading to cracking, spalling, and structural weakening. By measuring chloride content, engineers can evaluate whether the concrete provides adequate protection to reinforcement and whether any remedial action, such as surface treatment, cathodic protection, or concrete repair, is needed. This test is particularly useful for maintenance planning, quality control, and safety assessment of existing structures without causing significant damage to the member, especially when coring is difficult and cube samples can be used instead.

II. Industry/Employer expected outcome(s):

Students learn to measure chloride content in concrete to assess corrosion risk. Employers expect accurate testing, proper interpretation of results, and recommendations for maintenance or repair to ensure structural durability.

III. Course Level Learning Outcome (COs):

- CO2 - Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 7.1- Determine the chloride extent in the given RCC element using Rapid Chloride Test.

V. Relevant Affective Domain Related Outcome(s):

- Develops a sense of responsibility for ensuring the durability and safety of concrete structures.
- Encourages careful observation and accurate recording of test results.
- Promotes professional ethics in reporting and interpreting data.
- Fosters attention to detail and patience during non-destructive testing.
- Enhances teamwork and communication skills while performing field or laboratory tests.

VI. Relevant Theoretical Background:

The Rapid Chloride Test is a method used to determine the chloride ion content in concrete, expressed as a percentage by weight of cement. Chloride ions can penetrate concrete through diffusion, capillary absorption, or permeation, and high concentrations can lead to corrosion of embedded steel reinforcement, reducing structural durability.

The test works on the principle of chemical extraction and titration: A concrete sample (core or cube) is powdered, and chlorides are extracted using a suitable solution. The extracted solution is then analysed using titration or rapid test kits to quantify chloride content.

Factors affecting chloride penetration include:

- Thicker cover slows penetration.
- Lower permeability reduces chloride ingress.
- Marine or de-icing salt environments increase chloride exposure.
- Well-cured and older concrete generally have lower permeability.

This test provides a quick and reliable estimate of chloride concentration, enabling evaluation of corrosion risk and durability of reinforced concrete structures.

(a) Drilling of concrete element (b) Chloride content test

Figure No. 7: Rapid Chloride Test

(Source:https://share.google/images/MhjzkNGjP7vuyvapE,https://share.google/images/IkxMtmnFYU7ahgSrX)

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Drilling equipment	Sufficient to drill the concrete surface	1 No.	Per batch
2	Whatman filter paper No.1	--	4-5 Nos.	Per batch
3	Beaker	250mlcapacity	1 No.	Per batch
4	Conical flask.	250mlcapacity	1 No.	Per batch
5	Nitric acid.	6 N concentration	20-25 ml	Per batch
6	Silver nitrate.	0.2 N concentration	75-80 ml	Per batch
7	Ferric alum.	---	4-5 ml	Per batch
8	Nitrobenzene	----	15-20 ml	Per batch
9	Ammonium thiocyanate.	0.2 N concentration	As required	Per batch

VIII. Precautions to be followed:

- Ensure that the concrete sample (core or cube) is properly cleaned and free from dust, grease, or loose particles before testing.
- Use appropriate personal protective equipment (PPE) such as gloves, goggles, and lab coats while handling chemicals.
- Calibrate the Rapid Chloride Test kit or apparatus before starting the test to ensure accurate results.
- Avoid contamination of the sample with external chlorides (e.g., from handling, tools, or environment).
- Take representative samples from the structure to get an accurate measure of chloride content.

- Follow the manufacturer's instructions for reagent preparation, handling, and disposal.
- Record observations carefully and perform the test in a well-ventilated area to avoid inhalation of fumes.
- If coring is not possible, ensure that cube samples are from the same concrete batch and properly cured for reliable results.
- Repeat the test if results seem inconsistent or anomalous.

IX. Procedure:

1. Drill the target concrete surface to a depth of 5 mm and collect the powdered sample.
2. Weigh 1000 ± 5 g of the powdered concrete or mortar in a 2-liter beaker.
3. Add 1000 ml of distilled water (chloride-free) to the powder, stir well, and gently warm for 15 minutes.
4. Let the mixture settle at room temperature for 24 hours.
5. Take about 200 ml of the clear solution (supernatant) and pour it into a clean 250 ml beaker.
6. Filter the solution using Whatman No. 1 filter paper and collect the filtrate.
7. Pipette 50 ml of the filtrate into a 250 ml conical flask.
8. Add 5 ml of 6N nitric acid and a known volume (usually 25 ml) of 0.2 N silver nitrate solution.
9. Add 1 ml ferric alum and 5 ml nitrobenzene.
10. Shake the flask vigorously to form a precipitate.
11. Titrate the excess silver nitrate with 0.2 N ammonium thiocyanate until a faint reddish-brown color appears.
12. Note the volume of ammonium thiocyanate used.
13. Calculate the percentage of chloride in the sample using the formula:

$$\textbf{Chloride \%} = 0.00142 \times (X - Y)$$

Where:

X = volume of silver nitrate added (ml)
Y = volume of ammonium thiocyanate used (ml)
This gives the acid-soluble or water-soluble chloride content by weight of the mortar or concrete.

X. Observation Table:

a) Name of the Building: ………………………………………………………………

b) Address of the building: …………………………………………………………….

Name of building element	Trial No.	Color observed after titration	Volume of silver nitrate added (X) in ml	Volume of ammonium thiocyanate (Y) in ml	Chloride Content= 0.00142(X- Y) %	Average Chloride Content in %
	1					
	2					
	3					
	4					
	5					

Calculations:

For trial no.
The percentage of chloride for the building element is

Chloride percent = 0.00142(X- Y)

= ……………………………………..

= …………………………………….. %.

Average Chloride percent = …………………………………….

= …………………………………….. %.

Results: The average chloride content in percentage in tested……………………. (beam/column/slab) is found to be…………………..%.

XI. Interpretation of results:

XII. Conclusions:

XIII. Practical Related Questions:

(Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO. Write answers of minimum three questions.)

1. State the effect of chloride content on various properties of concrete.
2. State any four factors affecting the chloride content of concrete.
3. Write the tool used by you for drilling the concrete element.
4. State any four causes of chloride attack on concrete structures.
5. State the permissible limit of maximum chloride content for (i) pre-stressed concrete structures (ii) non-prestressed concrete structures.

<u>**Space for Answer**</u>

XIV. References / Suggestions for further Reading:

- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
- IS 14959-2:2001 – Method of Test for Determination of Water Soluble and Acid Soluble Chlorides in Mortar and Concrete.
- https://www.youtube.com/watch?v=OJ2pe9zSYHg

XV. Assessment Scheme:

Sr. No.	Performance Indicators	Weightage
A.	**Process Related (15 marks)**	**60%**
1.	Proper collection and preparation of concrete sample.	20%
2.	Correct handling of reagents and titration procedure.	20%
3.	Accuracy in performing Rapid Chloride Test steps.	20%
B.	**Product Related (10 marks)**	**40%**
4.	Correct calculation of chloride content.	20%
5.	Proper recording of observations and reporting results.	20%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 08 **Determine the depth of carbonation of beam, column or slab using phenolphthalein indicator.**

I. Practical Significance:

The practical significance of determining the depth of carbonation using phenolphthalein indicator lies in its ability to assess the risk of corrosion of the steel reinforcement within concrete structures. By identifying how far carbonation has penetrated, engineers can evaluate whether the protective alkaline environment around the steel has been compromised, which can lead to corrosion, structural weakening, and reduced service life. This information is crucial for maintenance planning, durability assessment, and making informed decisions about necessary repairs or protective measures to ensure the safety and longevity of beams, columns, slabs, and other concrete elements.

II. Industry/Employer expected outcome(s):

- This practical expects accurate carbonation depth assessment to ensure structural durability and prevent premature reinforcement corrosion. This enables timely maintenance, reducing repair costs and enhancing safety.

III. Course Level Learning Outcome (COs):

- CO 2- Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 8.1- Determine the deterioration of the given RCC element using phenolphthalein indicator.

V. Relevant Affective Domain Related Outcome(s):

- Develop a sense of responsibility for ensuring structural safety and durability.
- Appreciate the importance of preventive maintenance in extending the service life of concrete structures.
- Demonstrate commitment to quality control and adherence to industry standards during inspection and testing.

VI. Relevant Theoretical Background:

The depth of carbonation in concrete elements like beams, columns, or slabs is determined by applying a phenolphthalein indicator solution on a freshly exposed concrete surface. Carbonation lowers the pH of concrete from about 12-13 to below 9 by converting calcium hydroxide to calcium carbonate. Phenolphthalein turns pink in alkaline conditions (pH > 9) and remains colorless in carbonated, less alkaline zones (pH < 9). By measuring the distance from the surface to the boundary between the pink and colorless areas, the carbonation depth can be accurately assessed, indicating how far carbonation has penetrated the concrete.

Measurement of pH: Phenolphthalein solution indicates the change of pH level in the concrete.

- If the indicator turns purple, the pH is above 8.6.
- In practice, a pH of 8.6 may only give a faintly discernible slightly pink color.
- When the solution remains colorless, the pH of the concrete is below 8.6, suggesting carbonation.
- A fully-carbonated paste has a pH of about 8.4.
- A strong, immediate, color change to purple suggests a pH that is rather higher, perhaps pH 9 or 10.
- Normal concrete pore solution is saturated with calcium hydroxide and also contains sodium and potassium hydroxide; the pH is typically 13-14.

- Concrete with a pore solution of pH 10-12 is less alkaline than sound concrete but would still produce a strong color change with phenolphthalein indicator.

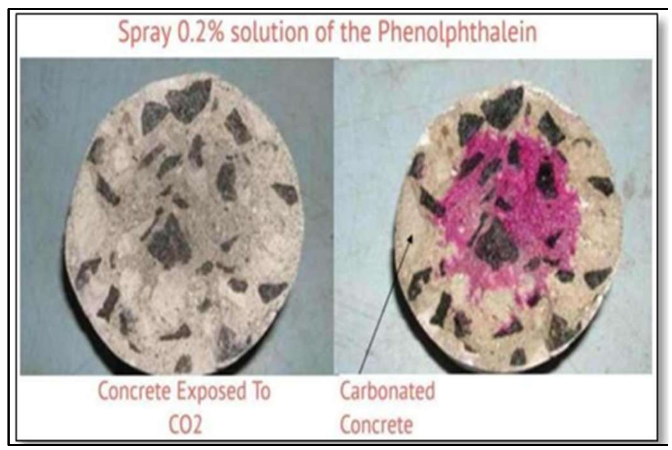
Alternative method of estimating depth of carbonation: The carbonation depth is approximately proportional to the square root of time. For example, if the carbonation depth is 1mm in a one-year-old concrete, it will be about 3mm after 9 years, 5mm after 25 years and 10mm after 100 years.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Phenolphthalein solution	0.2% concentration	300 ml approx.	Per batch
2	Measuring scale.	--	1 No.	Per batch
3	Physician's injection syringe or needle.	5 cc	1 No.	Per batch
4	Core sampler or drilling machine.	--	1 No.	Per batch

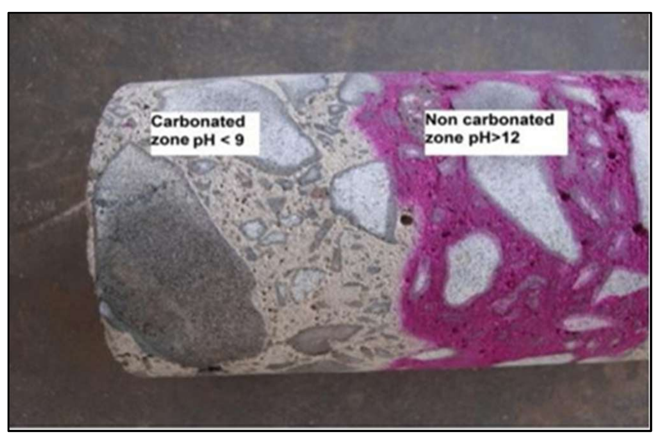
VIII. Experimental Set-up:

(a) Phenolphthalein solution as indicator.



(b) Concrete core before and after carbonation test.

(c) Measurement of depth of carbonation.



(d) Zones of carbonation.

IX. Precautions to be followed:

1. Wear appropriate PPE to avoid chemical and dust exposure.
2. Handle phenolphthalein carefully as it is flammable and can irritate skin or eyes.
3. Use tools like hammers or drills safely to prevent injury while exposing concrete surfaces.
4. Dispose of chemicals and concrete waste properly according to safety and environmental guidelines.

X. Procedure:

1. **Direct Surface Spraying Method:**
   1. **Expose Fresh Surface:**
      - Identify the test location on the beam, column, or slab.
      - Use a hammer and chisel or a concrete saw to break or cut the concrete and expose a fresh, clean, flat cross-sectional surface.
   2. **Clean the Surface:**
      - Remove any loose dust, debris, or dirt from the exposed surface using a brush or compressed air.
      - Ensure the surface is dry or slightly damp but free from water pooling.
   3. **Prepare Phenolphthalein Solution:**
      - Use a 1% phenolphthalein solution prepared by dissolving phenolphthalein crystals in ethanol or a mix of ethanol and water.
   4. **Apply Phenolphthalein Indicator:**
      - Spray or brush the phenolphthalein solution uniformly over the entire exposed surface.
      - Wait for about 1-2 minutes to allow the color reaction to develop.
   5. **Observe Color Change:**
      - Areas of the concrete that are alkaline ($pH > 9$) will turn pink or purple.
      - Carbonated areas ($pH < 9$) will remain colorless.
   6. **Measure Carbonation Depth:**
      - Using a ruler, caliper, or depth gauge, measure the distance from the outer surface to the color change boundary (pink to colorless).
      - Record the measurement as the carbonation depth.
2. **Core Sampling Method:**
   1. **Extract Concrete Core:**
      - Use a core drill machine to extract a cylindrical concrete core from the target location on the beam, column, or slab.
      - Typical core diameter is 50-100 mm, depending on the element size.
   2. **Split the Core:**
      - Once extracted, split or cut the core longitudinally to expose a fresh, clean cross-section.
      - This can be done with a core splitter or a diamond saw.
   3. **Prepare the Surface:**
      - Remove any loose particles and dust from the split surface using a brush or compressed air.
      - The surface should be clean and dry or slightly damp.
   4. **Apply Phenolphthalein Indicator:**
      - Spray or brush the phenolphthalein solution evenly on the split surface.
      - Allow 1-2 minutes for the color to develop.
   5. **Observe Color Change:**
      - Pink coloration indicates un-carbonated concrete.

- Colourless areas indicate carbonation.

6. **Measure Carbonation Depth:**
   - Measure the depth of the colourless zone from the outer surface inward using a ruler or calliper.
   - Record the carbonation depth for evaluation.

3. **Hammer and Chisel Method (Field Spot Test):**
   1. **Expose a Test Surface:**
      - At the test site on the beam, column, or slab, use a hammer and chisel to carefully remove a thin layer (approximately 5-10 mm) of surface concrete.
      - Aim to expose a fresh, clean surface without disturbing deeper layers.
   2. **Clean the Surface:**
      - Remove any dust or loose particles using a brush or air blower.
      - Ensure the surface is free from moisture or water pooling.
   3. **Apply Phenolphthalein Solution:**
      - Spray or brush phenolphthalein solution directly on the freshly exposed surface.
      - Allow 1-2 minutes for color development.
   4. **Observe Color Change:**
      - Pink areas represent un-carbonated concrete.
      - Colorless areas indicate carbonation.
   5. **Measure Carbonation Depth:**
      - Measure the depth of the colorless (carbonated) zone from the outer surface to the color boundary.
      - If deeper carbonation needs assessment, repeat chiseling in increments to expose further layers and apply phenolphthalein again.

XI. Observation and Calculations:

a. Name of the Building: ……………………………………………………………..

b. Address of the building: ……………………………………………………………

c. Date and time of visit: ……………………………………………………………...

d. Type of building/structure: ……………………………………………………....

e. Year of construction: …………………………………………………………….

Sr. No.	Name of Structural/Building element	Average depth of carbonation (mm)	Observed changed color of concrete	pH of concrete
1				
2				
3				
4				
5				

XII. Result:

1. The average depth of carbonation observed for ……………….. (beam/column/slab) is found to be ………….. mm and the change in colour observed in the tested concrete surface is found …………………………. (Unchanged grey / purple shade / pink shade).
2. The average depth of carbonation observed for ……………….. (beam/column/slab) is found to be ………….. mm and the change in colour observed in the tested concrete surface is found …………………………. (Unchanged grey / purple shade / pink shade).

XIII. Interpretation of results:

XIV. Conclusions:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What is carbonation in concrete, and how does it affect the reinforcement inside?
2. Why is phenolphthalein used as an indicator in the carbonation depth test?
3. What is the typical pH value of uncarbonated concrete, and how does carbonation change it?
4. How should the phenolphthalein indicator be applied on the exposed concrete surface during the test?
5. What does a deeper uncolored zone on the concrete surface indicate about the level of carbonation?

Space for Answer

XVI. References / Suggestions for further Reading:

- IS 516 (Part 5 / Section 3): 2021 — Carbonation Depth Test.
- IS 456 — Code of Practice for Plain & Reinforced Concrete.
- https://www.youtube.com/watch?v=BjMj1kFkZyE

XVII. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 09 **Determine the moisture content of beam, column or slab using Digital Moisture Meter.**

I. Practical Significance:

Determining the moisture content of concrete elements like beams, columns, or slabs is essential for assessing the durability, strength, and suitability of the structure for further construction or finishing works. High moisture content can indicate incomplete curing, leakage, or potential issues like corrosion of reinforcement and mold growth. Using a digital moisture meter provides a quick, non-destructive, and reliable method to assess moisture levels on-site. This helps in deciding when to proceed with surface treatments like painting, flooring, or waterproofing. It also aids in diagnosing problems in existing structures and ensures compliance with building quality standards.

II. Industry/Employer expected outcome(s):

- Accurate assessment of structural readiness for finishing works (like tiling, painting, or waterproofing) to prevent failures due to excess moisture.
- Early detection of moisture-related issues such as leakage or corrosion risk, ensuring better maintenance planning and structural durability.

III. Course Level Learning Outcome (COs):

- CO 2- Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 9.1- Predict the susceptibility of the RCC member against the dampness.

V. Relevant Affective Domain Related Outcome(s):

- Demonstrate a responsible attitude towards maintaining equipment and following safety protocols during the testing process.
- Show commitment to quality by valuing the importance of moisture measurement in ensuring the durability and safety of concrete structures.

VI. Relevant Theoretical Background:

There are three primary mechanisms that control the transport of fluids through concrete. They are permeation (saturated fluid flow under a pressure head), diffusion (fluid flow under a concentration gradient), and capillary suction (fluid flow due to capillary pressures in an unsaturated element).

Degree of saturation is calculated as: $Sr = \frac{M_a}{M_s} \, x \, 100$

Where,

S_r is the saturation ratio of specimen (%),

M_a is the moisture content at different soaking period in minutes;

M_s is the moisture content at the full saturation period (5-days).

Table: Saturation ratio of specimens prepared for mechanical tests.

Soaking time	0 min	30 min	90 min	200 min	5 days
Saturation ratio	0%	52%	87%	92%	100%

With decreasing degree of saturation, increase surface tension and compressive stress is found. It should be noted that as only physically absorbed water affects surface tension. At higher moisture content, water starts to fill capillary pores in the concrete, which is outside the range of surface tension.

The increase in concrete strength with decreasing saturation in the range of higher saturation ratio (52-92%) is assumed to come from the capillary suction effect leading to an almost isotropic compression of solid skeleton. As a result, the material behaves like a pre-stressed concrete of higher strength. At nearly saturated condition (92- 100%), an increase in compressive strength can be found. This could probably due to the pore pressure developed in the concrete.

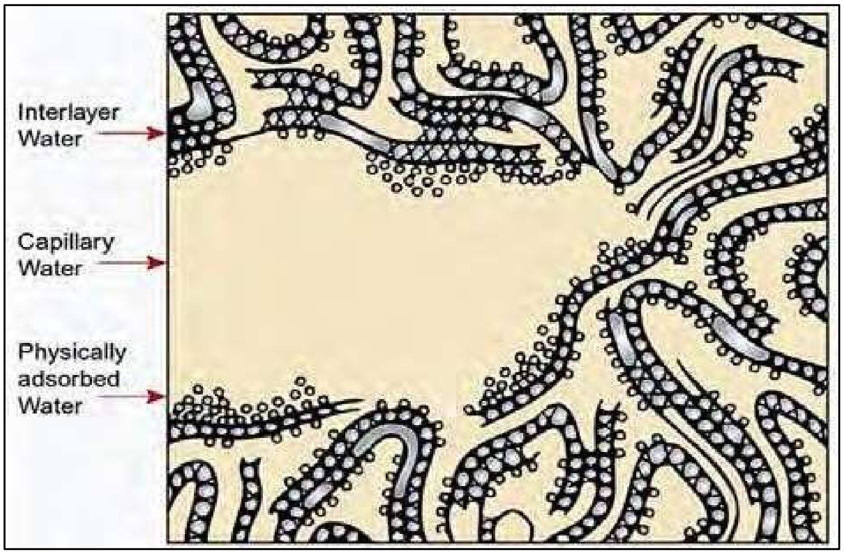


Figure: 9.1 Flow of water through concrete

Moisture content in concrete elements such as beams, columns, and slabs is a critical factor affecting the material's performance, durability, and structural integrity. Excess moisture can weaken concrete, reduce its compressive strength, and promote corrosion of embedded steel reinforcement, cause mold growth, and lead to failures in surface finishes like paints, adhesives, and flooring. Therefore, accurately measuring the moisture content is essential to ensure that the concrete has dried adequately before proceeding with further construction or finishing processes.

A Digital Moisture Meter provides a practical and non-destructive way to assess moisture levels in concrete. The device commonly operates on one of two fundamental principles:

Electrical Resistance/Conductance Method: Concrete's electrical resistance decreases as its moisture content increases because water contains dissolved ions that improve electrical conductivity. The meter applies a small alternating current through the concrete and measures the resistance. A lower resistance reading correlates to higher moisture content. This method is simple but can be influenced by factors like temperature, salt content, and concrete composition.

Dielectric Constant or Capacitance Method: This method uses electromagnetic waves to detect changes in the dielectric properties of concrete. Water has a much higher dielectric constant (~80) compared to dry concrete (~4-7). When moisture content increases, the concrete's overall dielectric constant rises, which affects the propagation of the electromagnetic field emitted by the meter's sensor. The device measures this change to estimate moisture content. This method is more sensitive and less affected by factors like temperature.

The moisture content readings from the digital meter are typically expressed as a percentage of water by weight or volume, allowing engineers to determine if the concrete meets the required dryness level specified in construction standards or manufacturer guidelines before applying coatings, sealants, or flooring.

Accurate moisture measurement helps prevent premature deterioration, enhances durability, and ensures the longevity of concrete structures by enabling informed decisions on curing duration, repair needs, or environmental control measures on-site.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Concrete Moisture Meter.	Moisture meter should be capable of in-situ moisture measurement up to depth of 300mm with the help of probe and should be operated on batteries.	1No.	Per batch
2	Compression testing machine.	Compression testing machine of 2000KN capacity.	1No.	-----
3	Curing tank.	Water tank of sufficient size.	1No.	-----
4	Measuring scale.	15 or 30 cm in length.	1 No.	Per batch
5	Thermostatically Controlled Oven.	Temperature range 105-110^{0}C.	1 No.	Per batch

VIII. Experimental Set-up:

Figure 9.2 Moisture meter test apparatus

Source: https://cdn11.bigcommerce.com/s-mj19jirgg/images/stencil/1280x1280/products/346/1070/7000-Moisture-Meter_main-01__89532.1634156876.jpg?c=1

IX. Precautions to be followed:

1. Wear appropriate PPE to avoid chemical and a mask during surface preparation and testing.
2. Ensure the surface is clean and dry to avoid slipping and ensure accurate moisture readings.
3. Handle the digital moisture meter carefully to prevent damage and ensure proper functioning.
4. Use ladders or scaffolding safely when measuring moisture at heights on beams or columns.

X. Procedure:

1. Measure the sides of five concrete cubes available in the laboratory.
2. Keep the same cubes in oven for drying for 24 hours.
3. Keep concrete cube in a tray for soaking such as 0 minutes (i.e. dry), 30 minutes, 90 minutes, 200 minutes, 5 days (full saturation).
4. Take out each cube from water at different soaking period. After wiping off excess water from the surface of the cube, measure the moisture content using moisture meter.
5. For measuring the, moisture content cleans the concrete surface of the beam, column, or slab to remove dust and debris. Turn on the digital moisture meter, select the appropriate setting for concrete, and place the sensor firmly on the surface. Record the moisture content reading once it stabilizes. Repeat the measurement at several points and calculate the average moisture content.
6. Calculate the saturation ratio (Sr) for five samples using Sr = (moisture content at particular soaking time / moisture content at full saturation) x 100
7. Crush each cube samples by applying crushing load using compression testing machine.
8. Correlate the moisture content to compressive strength for different saturation ratios.
9. Draw the graph of saturation ratio (Sr) v/s compressive strength (σ) on regular graph paper.

XI. Observation and Calculations:

Sr. No.	Particulars	Observation No.				
	Sample No.	**1**	**2**	**3**	**4**	**5**
	Soaking time in minutes	**0**	**30**	**90**	**200**	**5 days**
1	Moisture content at different saturation period (Ma).					
2	Moisture content of cube at full saturation period (5 days) (Ms).					
3	Saturation ratio (Sr) in percentage.					
	Compressive strength Determination.					
4	Actual cube size.					
5	Cross sectional area.					
6	Compressive load in Newton.					
7	Compressive strength in N/mm^2.					

Sample Calculation:

$$Sr = \frac{M_a}{M_s}\ x\ 100$$

For observation no.___

Sr =______________%

Compressive strength (σ) = $\frac{Crushing\ load}{C/s\ area}$ = ____________ N/mm²

XII. Result:

1. The Compressive strength of given concrete cube for Sr (….0%) is ………………….
2. The Compressive strength of given concrete cube for Sr(….%) is …………………..
3. The Compressive strength of given concrete cube for Sr (… %) is……………………
4. The Compressive strength of given concrete cube for Sr (…. %) is …………………...
5. The Compressive strength of given concrete cube for Sr (100%) is …………………..

XIII. Interpretation of results:

XIV. Conclusions:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Why is it important to clean the concrete surface before taking moisture measurements?
2. How does the digital moisture meter detect moisture in concrete?
3. What should you do if you get significantly different moisture readings at different points on the same slab or beam?
4. Where should the Digital Moisture Meter pins or probes be placed on a concrete surface to get an accurate moisture content reading?
5. What should you do to ensure the Digital Moisture Meter displays a stable reading before recording the moisture content of the structural member?

Space for Answer

XVI. References / Suggestions for further Reading:

- The instrument calibration should be checked before and after the test to ensure accuracy.
- IS 2386 (Part 3):1963 — Methods of Test for Aggregates for Concrete (includes moisture content tests).
- IS 456 — Code of Practice for Plain & Reinforced Concrete.

XVII. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 10 **Determine the corrosion extent of reinforcing bar of beam, column or slab using Half-cell Potentiometer.**

I. Practical Significance:

The half-cell potentiometer test is a non-destructive method used to assess the corrosion extent of reinforcement in beams, columns, or slabs by measuring the potential difference between steel and a reference electrode. It helps identify corrosion-prone areas in concrete structures without causing damage, enabling early detection of corrosion risk. This allows engineers to plan timely preventive measures and suitable repair strategies such as cathodic protection, coatings, or rehabilitation. By providing reliable data on the durability of reinforced concrete, the test ensures structural safety while reducing long-term maintenance costs.

II. Industry/Employer expected outcome(s):

- Accurate identification of corrosion-prone reinforcement areas with recommendations for timely and cost-effective repair/rehabilitation measures.
- Enhanced structural safety, durability, and service life of concrete structures, ensuring reduced maintenance costs and compliance with standards.

III. Course Level Learning Outcome (COs):

- CO 2- Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 10.1 Determine the corrosion extent in the given RCC member using Half-cell Potentiometer.

V. Relevant Affective Domain Related Outcome(s):

- Develops a sense of responsibility towards ensuring safety, durability, and sustainability of concrete structures.
- Encourages professional ethics and commitment in adopting preventive maintenance and rehabilitation practices.

VI. Relevant Theoretical Background:

Corrosion of reinforcement in concrete is one of the most common causes of deterioration in reinforced concrete structures. Since steel is embedded in alkaline concrete, a passive protective film normally prevents corrosion. However, factors like carbonation, chloride ingress, moisture, and oxygen exposure can break this passive layer, initiating corrosion. Early detection of such corrosion is essential for structural durability and safety.

The Half-Cell Potential Method (as per ASTM C876) is a non-destructive electrochemical technique used to assess the likelihood of corrosion activity in embedded reinforcement. The principle is based on measuring the electrical potential difference between the reinforcing steel (connected as one terminal) and a standard reference electrode (commonly a copper–copper sulfate electrode or CSE) placed on the surface of the concrete.

When the reference electrode is placed on a moist concrete surface, an electrical circuit is formed with the reinforcing steel, allowing a voltmeter to measure the half-cell potential. The measured potential values indicate the probability of corrosion rather than the actual rate of metal loss.

ASTM C876 Probability Ranges (using Cu–$CuSO_4$ electrode):

Potential > –200 mV → 90% probability of no corrosion.

Potential between –200 mV and –350 mV → Uncertain (corrosion may or may not occur).

Potential < –350 mV → 90% probability of active corrosion.

The test requires ensuring good electrical continuity of reinforcement, moistening the concrete surface to reduce resistance, and systematically recording potential values across a grid for mapping corrosion-prone areas.

Typical ranges of half-cell potentials of rebar in concrete:

Conditions	Potential values (mV/CSE*)
Humid, chloride free concrete	-200 to +100
Chloride contaminated wet concrete	-600 to -400
Water saturated concrete without oxygen	-1000 to -900
Humid carbonated concrete	-400 to +100
Dry, carbonated concrete	0 to +200
Dry concrete	0 to +200

VII. Required resources/equipment:

Sr. No.	Particulars	Specification		Quantity	Remark
1	Half-cell potentiometer.	Brand:	Avantech	1No.	Per batch
		Voltage:	220 V		
		Power Source:	Electric		
		Frequency:	50 Hz		
2	Rebar corrosion tester or Locate manually	Bosch Rebar Locator, D-Tech 150.		1No.	Per batch
3	Measuring scale	15 cm or 30 cm.		1No.	Per batch

VIII. Experimental Set-up:

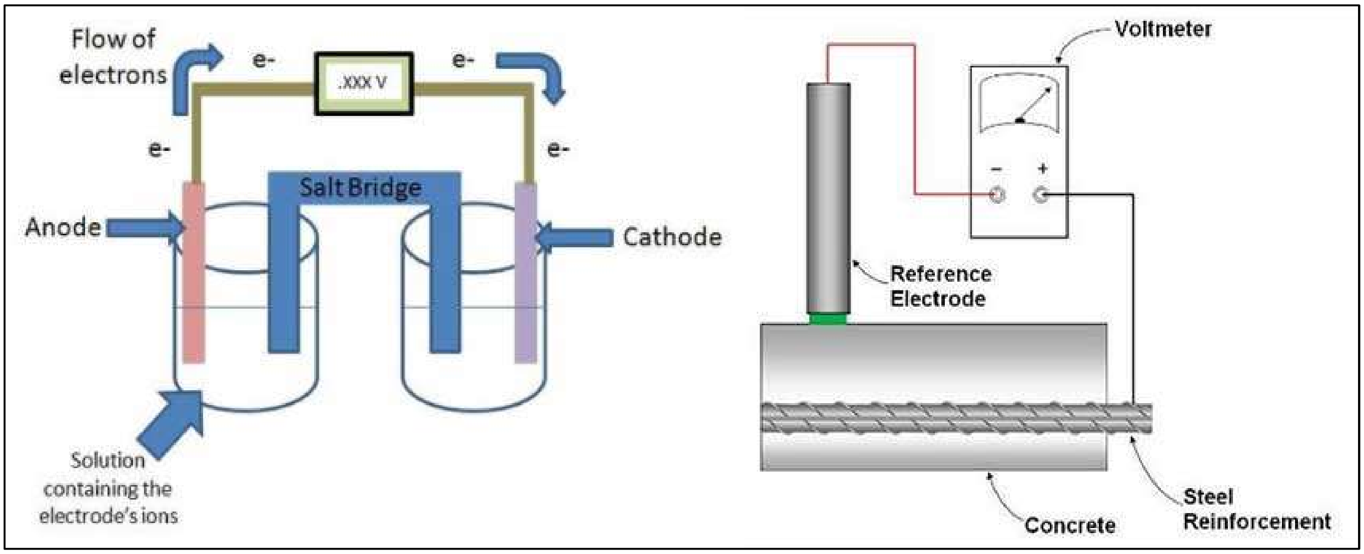


Figure 10.1 Moisture meter test apparatus

(Source: https://www.giatecscientific.com/education/what-is-the-half-cell-potential-test/)

IX. Precautions to be followed:

1. Ensure the concrete surface is free from contaminants for accurate readings.
2. Avoid moving the reference electrode too quickly; maintain steady contact.
3. Do not use the instrument in extremely wet or dry conditions that may give false potentials.

X. Procedure:

1. Surface Preparation

- Clean the concrete surface above the reinforcing steel to remove dust, laitance, paint, or any loose material.
- Ensure the concrete is dry or slightly damp (as per instrument guidelines) for proper electrical contact.

2. Setup of Half-cell Potentiometer

- Connect the reference electrode (commonly a copper/copper sulfate electrode, Cu/$CuSO_4$) to the positive terminal of the potentiometer.
- Connect the reinforcing steel (via exposed steel or rebar) to the negative terminal of the potentiometer.

3. Establish Electrical Connection

- If the steel is not directly accessible, drill a small hole to reach the rebar and insert a metallic wire to make electrical contact.
- Ensure good contact using conductive gel or saturated sponge if required.

4. Measurement

- Place the reference electrode on the concrete surface, keeping it in contact via a wet sponge or small puddle of saturated solution.
- Read the potential difference (voltage) displayed on the potentiometer.
- Move the reference electrode along the surface to measure at multiple points to locate the corrosion-prone areas.

5. Interpretation of Results

- Compare the measured potential values with standard corrosion probability charts (ASTM C876).
- More negative potential → higher probability of corrosion.
- Less negative potential → lower probability of corrosion or passive steel.
- Map the readings to identify zones with active or developing corrosion.

XI. Observation and Calculations:

Sr. No.	Distance from origin	Half-cell potential (mv)	Grade range (mv)	Probability of corrosion

Sample Calculation:

For different locations from origin point, evaluate the range of corrosion and find the location of corrosion.

XII. Result:

1. The corrosion at ……………. distance from origin is …………….
2. The corrosion at ……………. distance from origin is …………….
3. The corrosion at ……………. distance from origin is …………….

XIII. Interpretation of results:

XIV. Conclusions:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Why is it important to place the reference electrode directly on the concrete surface, and how does its position affect the potential reading?
2. What does a highly negative potential reading indicate about the condition of the reinforcing steel, and why?
3. Why do we take readings at multiple points on a beam, column, or slab rather than at a single location?
4. Why must the concrete surface be moistened before placing the Half-Cell electrode to measure corrosion potential in a beam, column, or slab?
5. What connection must be made between the reinforcement and the Half-Cell Potentiometer to obtain a correct corrosion potential reading?

Space for Answer

XVI. References / Suggestions for further Reading:

- The instrument calibration should be checked before and after the test to ensure accuracy.
- IS 516: Part 5, Section 2 – 2022.This standard provides guidelines for performing the Half-cell Potentiometer test in India, aligning with ASTM C876.
- https://www.youtube.com/watch?v=c4JL77qhAdc&embeds_referring_euri=https%3A%2F%2Fchatgpt.com%2F&source_ve_path=MjM4NTE

XVII. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			Dated sign of Teacher
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 11 **Determine the extent of efflorescence at minimum three locations in given damaged or undamaged masonry or concrete structure.**

I. Practical Significance:

Determining the extent of efflorescence at a minimum of three locations in a masonry or concrete structure provides important practical insights into the condition of the structure. By observing and measuring efflorescence at multiple points, engineers can identify areas where moisture is penetrating the material, which is an early indicator of potential water-related damage. It also helps evaluate the quality and durability of the construction materials, as excessive salt deposits may suggest poor material quality or improper curing. Furthermore, mapping the distribution and severity of efflorescence guides maintenance and repair efforts, enabling targeted interventions such as waterproofing, surface treatment, or material replacement to prevent further deterioration and enhance the long-term durability of the structure.

II. Industry/Employer expected outcome(s):

- Assess the structural health by identifying moisture-affected and efflorescence-prone areas.
- Enable targeted maintenance and repair decisions to enhance durability and reduce costs.

III. Course Level Learning Outcome (COs):

- CO 2- Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 11.1-Identify the nature of efflorescence in given type of structure.

V. Relevant Affective Domain Related Outcome(s):

- Develops awareness and responsibility for maintaining structural health.
- Encourages careful observation and accurate recording of efflorescence.
- Fosters ethical commitment to recommending safe and effective repairs.

VI. Relevant Theoretical Background:

Efflorescence is the crystalline deposit of soluble salts that appears on the surface of masonry, concrete, or other porous building materials when water migrates to the surface and evaporates. It occurs when water dissolves salts present in the material or from external sources, carries them to the surface, and leaves them behind as the water evaporates. Efflorescence itself does not usually compromise structural integrity, but it is an indicator of moisture ingress, which can lead to long-term deterioration, corrosion of reinforcement, or decay of masonry units.

The extent of efflorescence can be influenced by factors such as the quality of materials, construction practices, exposure to moisture, and environmental conditions. By assessing efflorescence at multiple locations, engineers can identify vulnerable areas, evaluate material durability, and plan preventive or corrective measures, such as waterproofing, improved drainage, or salt extraction treatments.

Degree of Efflorescence: The extent efflorescence in the masonry or concrete can be defined in terms of degree of efflorescence as given in Table 11.1.

Sr. No.	Observations of % area coverage of salts	Degree of efflorescence
1	When there is no perceptible deposit of efflorescence.	Nil
2	When thin deposit is on area less than 10 % of the exposed brick area.	Slight
3	When deposit is up to 50 % of the exposed brick without powdering.	Moderate
4	When deposit is more than 50 % of the exposed brick without powdering.	Heavy
5	When deposit is more than 50 % of the exposed brick with powdering.	Serious

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	Shallow flat bottom dish.	Glass, porcelain or glazed stoneware material	2 Nos.	Per batch
2	Measuring Scale.	1 mm accuracy.	1 No.	Per batch
3	Distilled water.	--	4-5 liters	Per batch
4	Bricks sample.	From damaged/undamaged part.	5 Nos.	Per batch
5	Concrete sample.	From damaged/undamaged part.	1 No.	Per batch
6	HCl acid.	Concentrated form.	200 gm/m^2	Per batch
7	Cleaning brush.	--	1 No.	Per batch
8	Sponge	--	1 No.	Per batch

VIII. Experimental Set-up:

Fig.11.1 Bricks in circular tray

Fig.11.2 Efflorescence observed after immersion

Fig 11.3 Efflorescence in concrete

Fig 11.4 Efflorescence in concrete

IX. Precautions to be followed:

1. Ensure the surface is clean and dry before observation to avoid misleading results.
2. Take measurements at multiple locations to get a representative assessment of the structure.
3. Avoid disturbing the efflorescence deposits during examination to maintain accurate documentation.

X. Procedure:

A. Efflorescence test on masonry bricks:

1. Arrange the visit to accessible building nearby and take out 5 bricks safely from damaged or undamaged part of the building.
2. Remove the plastered part of the brick taken clearly without breaking the brick as a whole and identify the type and size of brick by measuring its dimensions.
3. Maintain the warm and well-ventilated room at a temperature ranging between 200C to 300C for this test.
4. Take the shallow flat bottom dish of size 180x180 mm in plan with 40mm height for square shaped and 200 mm dia. x 40 mm depth for cylindrical shaped.
5. Fill this dish with sufficient quantity of distilled water up to 25 mm depth using measuring scale required for complete saturation.
6. Keep the 5cleaned bricks in the water by immersing its header end, so that the immersed brick will absorb the water completely as per its full capacity.
7. Allow to evaporate the surplus water will evaporate and bricks will appear to be dry within minimum 48 hours or more.
8. Now again add same quantity of water in the tray containing bricks. Allow to absorb the water by bricks completely with evaporation of excess water.
9. Observe the dry surface of brick for the presence of soluble salts in the form of white or grey spots in the average % area coverage by efflorescence.
10. Define the degree of efflorescence of bricks using Table 1.

B. Efflorescence test on concrete element: As there is no standard test method to access the extent of efflorescence in concrete material, one can take judgment by following the procedure given below.

1. Arrange the visit to accessible building nearby and identify the doubtful concrete surface where chances of efflorescence are more.
2. Clean it properly by removing dust present on the surface if any.
3. Prepare the diluted HCl from its concentrated form so that the quantity of HCl acid would be 200 gm/m^2.
4. Apply the prepared diluted HCl on the target concrete surface using a sponge with thickness 0.5 mm uniformly.
5. Remove the concrete surface using sharp edge up to depth 0.01 mm uniformly.
6. Observe the concrete surface after end of the reaction.
7. Observe the surface of concrete thoroughly, if the concrete surface is dark, medium dark or light, then it indicates high, medium or low degree of efflorescence respectively.

XI. Observation and Calculations:

a. Name of the Building: ……………………………………………………………

b. Address of the building: ………………………………………………………….

c. Condition of the building ....(damaged/undamaged)

- **Observation table for efflorescence test in masonry brick:**

Type of Brick	Size of Brick (L x B x t) mm	Observed Degree of Efflorescence in					Average Degree of Efflorescence
		Brick Sample 1	Brick Sample 2	Brick Sample 3	Brick Sample 4	Brick Sample 5	

- **Observation table for efflorescence test in concrete element:**

Name of Building Element	**Observed color of the concrete surface** (Dark/Medium dark/light)	**Degree of efflorescence** (High/Medium/Low)

XII. Result:

1. The degree of efflorescence observed in the bricks of damaged/undamaged wall is found to be (Nil/Slight/Moderate/Heavy/Serious).
2. The efflorescence is ……………………… (Removable /non-removable) from the damp wall.
3. As per the observed extent of efflorescence in tests bricks, it is required to remove efflorescence of damaged part by (water washing/strong brushing/vinegar spraying)
4. The effect of efflorescence in the building is mainly caused due to …………………………….(use of damp brick in construction/entry of moisture after construction).
5. The degree of efflorescence in tested concrete element is………..……….. (High/Medium/Low).

XIII. Interpretation of results:

XIV. Conclusions:

XV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Why is it important to examine multiple locations in a structure rather than a single spot when assessing efflorescence?
2. How does the presence and extent of efflorescence indicate moisture movement within masonry or concrete?
3. What precautions must be taken during observation to ensure accurate recording of efflorescence deposits?
4. How do you visually assess and record the thickness or coverage of efflorescence at each selected location on the structure?
5. What tool or method can be used to gently scrape the surface to determine whether the efflorescence is loose (surface level) or firmly bonded (indicating deeper moisture movement)?

Space for Answer

XVI. References / Suggestions for further Reading:

- IS 2250:1981 – Guide for Measurement of Efflorescence on Masonry Surfaces
- IS 456: 2000 – Code of Practice for Plain and Reinforced Concrete.
- https://www.youtube.com/watch?v=2pu2SxAK-Q8

XVII. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 12 **Prepare the structural audit report mentioning budget estimation, task force, equipment's and methodology for the given damaged structure.**

I. Practical Significance:

A structural audit report provides a detailed assessment of the existing condition of a damaged structure, identifying safety risks, potential failures, and necessary repair measures. By incorporating budget estimation, it helps owners and stakeholders plan financial resources effectively, preventing unforeseen expenses. Defining the task force ensures that qualified professionals such as structural engineers, surveyors, and skilled technicians are assigned appropriate roles for accurate evaluation and reporting. Listing the required equipment-like non-destructive testing tools, crack monitoring devices, and moisture meters-ensures systematic and precise data collection. Clearly outlining the methodology, including visual inspections, material testing, and structural analysis, ensures consistency and reliability of the findings. Ultimately, such a report guides decision-making for repair, retrofitting, or strengthening, thereby enhancing safety, durability, and cost-efficiency of the structure.

II. Industry/Employer expected outcome(s):

- The structural audit report helps industry assess the true condition of the damaged structure, enabling informed decisions on repairs or retrofitting.
- It provides clear guidance on budget, resources, and methodology. Ultimately, it ensures safety, compliance, and cost-effective maintenance.

III. Course Level Learning Outcome (COs):

- CO 2- Undertake the Non-Destructive Testing (NDT) to carry structural audit of structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 12.1 Predict the stability of existing building structure under consideration.

V. Relevant Affective Domain Related Outcome(s):

- The practical develops responsibility by ensuring accurate evaluation of structural safety.
- It fosters professional ethics through unbiased and honest reporting.
- It also enhances teamwork and collaboration among the inspection task force.

VI. Relevant Theoretical Background:

Structural auditing is the systematic evaluation of a building or infrastructure to determine its current condition, safety, and serviceability. It involves understanding the behavior of materials (concrete, steel, and masonry), load distribution, and structural design principles. Non-destructive testing methods, visual inspections, and structural analysis theories are applied to detect cracks, corrosion, settlement, and other forms of deterioration. Budget estimation integrates cost analysis and resource planning, while task force organization ensures that qualified personnel carry out inspections efficiently. The methodology combines engineering judgment, standardized procedures, and compliance with codes (e.g., IS 13311, IS 456) to provide a reliable assessment and recommendations for maintenance, repair, or retrofitting.

Budget Estimation:

The budget for conducting a structural audit of the damaged structure includes costs related to manpower, equipment, non-destructive testing, sampling, and laboratory investigations. Approximately lakhs or rupees are required for a complete audit, covering professional fees, testing equipment, mobilization, and report preparation. If immediate minor remedial works are undertaken after the audit, such as epoxy injection, spalling repairs, or rebar replacement, an additional expenditure may be needed, depending on the severity and extent of the damage. This ensures that both inspection and preliminary repair costs are considered in the financial planning.

Task Force:
A specialized task force is necessary to execute the audit effectively. The team typically consists of a lead structural engineer to guide the process and sign off on recommendations, a senior field engineer to supervise site operations, and trained technicians to conduct non-destructive tests such as rebound hammer, ultrasonic pulse velocity, and half-cell potential measurements. Additional members include surveyors for data collection, laboratory technicians for testing core samples, and a safety officer to ensure safe working conditions. Support staff, such as administrative or drafting personnel, contribute to documentation and final reporting. This multidisciplinary approach ensures accuracy, reliability, and professional accountability throughout the audit.

Equipment:
The audit requires a combination of visual inspection tools and advanced testing equipment. Key instruments include the rebound hammer, ultrasonic pulse velocity tester, cover meter, half-cell corrosion meter, and carbonation testing kits. Supporting tools such as crack gauges, moisture meters, and digital cameras are essential for mapping and recording damage. Core drilling machines, scaffolding, and safety harnesses are used for accessing and sampling damaged areas. Laboratory facilities are required for core strength testing and chemical analysis. These overall equipment's are ensuring the audit is performed systematically and in compliance with standards.

Methodology:
The methodology of the structural audit begins with the collection of available drawings, past maintenance records, and any prior inspection reports. This is followed by a detailed visual inspection and systematic mapping of all visible defects such as cracks, spalling, seepage, and corrosion. Non-destructive testing methods like rebound hammer, ultrasonic pulse velocity, and half-cell potential are then applied to evaluate the strength, quality, and durability of the structural elements. Selective core sampling and laboratory analysis provide further insights into material properties, carbonation, and chloride content. The collected data is analyzed to assess the structural integrity and serviceability of the building. Finally, the audit report is prepared with photographic documentation, test results, structural assessment, cost estimation, and prioritized recommendations for repair or retrofitting. This structured methodology ensures a comprehensive and reliable outcome.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	State Schedule of Rates (SSR)	Item rates	01	Per batch
2	Brochure of equipment's	Construction equipment's.	Required	Per batch
3	Labor charges and acts	GR about labour charges	Required	Per batch
4	Data base of materials	Standard materials	Required	Per batch

VIII. Precautions to be followed:

1. Ensure strict safety measures on site by using PPE, barricades, scaffolding, and harnesses to protect the audit team and occupants.
2. Avoid further weakening of the damaged structure while carrying out non-destructive tests or core sampling.
3. Calibrate and handle all testing equipment carefully to obtain accurate and reliable results.
4. Follow relevant IS codes, safety standards, and professional engineering practices throughout the audit process.

IX. Procedure:

1. **Preliminary Study:** Collect available structural drawings, design details, previous maintenance or audit reports, and usage history of the building.
2. **Visual Inspection**: Carry out a systematic walk-through survey to identify visible defects such as cracks, spalling, seepage, rusting, and deformations; document with photographs and sketches.
3. **Non-Destructive Testing (NDT):** Perform rebound hammer, ultrasonic pulse velocity (UPV), half-cell potential, carbonation depth, and cover meter tests to assess in-situ material strength and durability.
4. **Sampling and Laboratory Testing:** Extract core samples, reinforcement samples, or powder samples as needed and send them to the laboratory for compressive strength, chloride, and carbonation analysis.
5. **Data Analysis and Structural Assessment:** Interpret field and lab results, compare with codal requirements, and evaluate the structural capacity, safety, and serviceability of the building.
6. **Report Preparation:** Prepare a comprehensive report including observations, test data, photographs, analysis, budget estimation, and prioritized recommendations for repair, retrofitting, or strengthening.

X. Observation and Calculations:

a) Site Name: ………………………………………………….

b) Name of contractor (if employed): ………………………………………………….

c) Location of site: ……………………………………………….

d) Date of visit: …………………………………………………

A. Observation table:

Sr. No	Location/ Member	Type of Distress Observed	Severity (Low / Medium / High)	Probable Cause	Remarks / Action Suggested

B. Checklist for budget estimation of repair materials:

Sr. No.	Type of Distress observed	Repair Material Required	Unit	Estimated quantity of material required	Rate/Unit	Amount

C. Checklist for budget estimation of equipment's:

Sr. No.	Type of Distress observed	Equipment required	Rent/Hour	No of Hours required	Amount

D. Checklist for budget estimation of equipment's:

Sr. No.	Role/Designation	No of Persons	Daily Wages	Amount

XI. Result:

XII. Interpretation of results:

XIII. Conclusions:

XIV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. Write any four objectives of budget estimation for damaged structures.
2. State any four advantages of budget estimation in civil work construction.
3. When and where, it is necessary to purchase equipment’s rather than hire (any two points).
4. Write any four influencing factors while budget estimation of a given structure.
5. Sate any three safety factors are to be considered while budget estimation of a damaged structures.

Space for Answer

XV. References / Suggestions for further Reading:

- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete (for design, durability, and structural checks).
- IS 13311 (Part 1 & 2):1992 – Non-Destructive Testing of Concrete (Part 1: Ultrasonic pulse velocity, Part 2: Rebound hammer).
- IS 3370 (Part 2):1965 – Code of Practice for Concrete Structures for the Storage of Liquids (for seepage and durability assessment).
- IS 4082:1996 – Code of Practice for Drying Shrinkage of Concrete (relevant for cracking analysis).
- IS 13828:1993 – Guidelines for Improving Earthquake Resistance of Low Strength Masonry Buildings (for structural safety and retrofitting).
- IS 1905:1987 – Code of Practice for Structural Use of Unreinforced Masonry (for masonry assessment).
- IS 1645:1988 – Code of Practice for External Works for Building Construction (for minor repair and durability considerations).
- IS 13311 (Part 3):1992 – Carbonation and chloride penetration tests on concrete (if chemical durability testing is conducted).

XVI. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 13 **Prepare the check list of required materials with current market rates required for repair of the given damaged load bearing or framed structure.**

I. Practical Significance:

Choosing the right materials ensures that the repaired structure regains its strength, stiffness, and durability. Reinforcements and steel plates restore load paths and continuity, while bonding agents, grouts, and patching mortars ensure good adhesion and prevent weak interfaces. Corrosion protection, waterproofing, and admixtures guard against future deterioration from moisture, chlorides, and shrinkage. Proper formwork and curing help the repair concrete gain full strength and avoid cracking. Altogether, this checklist helps in estimating cost, ensuring quality, and restoring structural safety without under- or over-specifying materials.

II. Industry/Employer expected outcome(s):

- The repaired structure must regain full structural integrity and safety.
- Repairs should be durable, cost-effective, and require minimal future maintenance.
- All work must comply with standards and be completed within the scheduled timeline.

III. Course Level Learning Outcome (COs):

- CO 3- Propose the relevant materials for undertaking the repair of given structures.

IV. Laboratory Learning Outcome (LLO):

- LLO 13.1- Compare the repairing materials in terms of various criterion.

V. Relevant Affective Domain related Outcome(s):

- Demonstrate a responsible attitude toward safety, quality, and structural integrity during repair work.
- Show commitment to ethical practices by selecting appropriate materials and adhering to standards.
- Value teamwork and communication in coordinating with engineers, supervisors, and laborers for effective execution.

VI. Relevant Theoretical Background:

Repair and rehabilitation of damaged load-bearing or framed structures is a critical area in civil engineering, aiming to restore or enhance the structural capacity and durability of buildings or infrastructure that have deteriorated due to age, environmental exposure, overloading, poor construction, or accidental damage.

- **Structural Systems (Load-Bearing vs. Framed Structures):**
  A load-bearing structure transfers loads through walls directly to the foundation, while a framed structure uses beams and columns to support loads, with walls serving mostly as partitions.
  Understanding the load paths is crucial to identify which elements have failed and how they affect overall stability.

- **Causes of Structural Damage:**
  Common causes include corrosion of reinforcement, cracking due to shrinkage or overload, settlement, poor workmanship, seismic forces, and environmental degradation.
  Identifying the cause is essential before selecting the appropriate repair technique.

- **Repair Materials and Techniques:**

  Materials like cement, epoxy resins, non-shrink grouts, steel plates, FRP composites, and corrosion inhibitors are used depending on the nature of damage.

  Techniques include crack injection, section enlargement, external strengthening, rebar replacement, and surface patching.

- **Principles of Structural Repair**:

  Ensure compatibility between existing and new materials (e.g., thermal expansion, strength).

  Restore the original or improved load-carrying capacity.

  Protect against future deterioration through waterproofing, coatings, and corrosion control.

- **Standards and Guidelines:**

  Indian Standards (IS) such as IS 456:2000, IS 15988:2013 (repair and rehabilitation of RC structures), and IS 13311 (NDT methods) provide technical guidance.

  International codes like ACI, BS, and Eurocodes may also be referenced for advanced techniques.

- **Testing and Evaluation:**

  Non-destructive testing (NDT) methods like rebound hammer, ultrasonic pulse velocity, and half-cell potential help assess concrete quality and reinforcement corrosion.

  Post-repair testing ensures the success and safety of the rehabilitation.

- **Economic and Environmental Considerations:**

  Repairing structures is often more economical and environmentally sustainable than demolition and reconstruction.

  A well-planned repair extends service life, conserves materials, and reduces waste.

  In conclusion, successful structural repair requires a solid understanding of structural behavior, damage mechanisms, material science, and engineering judgment. This theoretical foundation ensures practical work is safe, effective, and compliant with standards.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	State Schedule of Rates (SSR)	Item rates	01	Per batch
2	Labor charges and acts	GR about labour charges	Required	Per batch
3	Data base of materials	Standard materials	Required	Per batch

VIII. Precautions to be followed:

1. Assess the structural damage thoroughly and ensure the area is stable before starting repairs.
2. Use only compatible materials and follow proper surface preparation and curing procedures.
3. Always wear appropriate personal protective equipment (PPE) and ensure site safety.
4. Avoid loading the repaired structure prematurely and monitor the repair for long-term performance.

IX. Procedure:

1. **Assess Damage and Define Repair Scope:** Inspect the damaged structure thoroughly to identify affected elements and specify the types of repairs needed (e.g., crack filling, rebar replacement, surface patching).
2. **List All Required Materials:** Based on the repair scope, prepare a detailed list of materials such as cement, aggregates, steel reinforcement, epoxy, grout, coatings, formwork, and safety gear, including specifications and grades.
3. **Collect Current Market Rates:** Obtain quotations from multiple local suppliers for each material, including delivery and taxes. Verify rates with online resources or published price schedules for accuracy.
4. **Calculate Adjusted Quantities and Costs:** Account for material wastage, transportation, handling, and storage costs by adding standard percentage allowances. Calculate final unit rates and total estimated costs.
5. **Prepare and Review the Checklist:** Organize the data into a clear tabular format showing material names, units, quantities, unit rates, adjustments, and total costs. Review with experienced personnel to ensure accuracy before finalizing.

X. Observation and Calculations:

a) Site Name: ………………………………………………….

b) Name of contractor (if employed): ………………………………………………….

c) Location of site: ……………………………………………….

d) Date of visit: …………………………………………………

Check list of material:

Sr. No	Damage Observed	Required Material	Specification / Grade	Quantity Required	Unit	Rate (₹)	Amount (₹)

Sr. No	Damage Observed	Required Material	Specification / Grade	Quantity Required	Unit	Rate (₹)	Amount

XI. Result:

XII. Interpretation of results:

XIII. Conclusions:

XIV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. How do you determine the appropriate repair material for different types of structural damage (e.g., cracks, spalling, and corrosion)?
2. What steps must be followed to ensure proper bonding between the old concrete surface and the new repair material?
3. Why is it important to include allowances for wastage and transportation when preparing a material cost checklist for structural repairs?
4. Which material specifications (e.g., grade of cement, type of steel, sand and aggregate quality) must be included in the checklist when estimating materials for repair?
5. How do you determine and verify the current market rates for each material listed in the repair checklist?

Space for Answer

XV. References / Suggestions for further Reading:

- IS 15988:2013 – Guidelines for Repair and Rehabilitation of Reinforced Concrete Structures (Bureau of Indian Standards)
- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
- Concrete Technology" by M.S. Shetty.
- Maintenance and Repair of Civil Structures" by B.L. Gupta & Amit Gupta.
- CPWD Specifications and Schedule of Rates (SOR).
- PWD State Schedules of Rates.

XVI. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 14 **Prepare the visit report on materials and techniques required for repairing of spalling/delamination of plaster by visit/demo video.**

I. Practical Significance:

The repair of spalling and delaminated plaster holds significant practical importance for the structural integrity, durability, and aesthetics of a building. Ignoring these issues can lead to deeper structural damage, especially if reinforcement corrosion is involved. Timely repairs prevent further moisture ingress, reduce the risk of falling debris, and extend the service life of the building. Moreover, using proper materials and techniques ensures that repairs are durable and cost-effective in the long run. It also improves indoor air quality by eliminating damp areas prone to mold growth. From both maintenance and safety perspectives, addressing plaster spalling is a critical component of building upkeep.

II. Industry/Employer expected outcome(s):

- Ensure long-term structural integrity and safety through proper identification and repair of spalling/delaminated plaster.
- Enhance building durability and appearance by applying industry-recommended materials and techniques.
- Minimize future maintenance costs and downtime by addressing root causes and preventing recurring issues.

III. Course Level Learning Outcome (COs):

- CO 4 - Apply the relevant method of repair for the masonry work.

IV. Laboratory Learning Outcome (LLO):

- LLO 14.1-Undertake the repairing of plaster the given masonry.

V. Relevant Affective Domain Related Outcome(s):

- Demonstrates responsibility and commitment to maintaining structural safety and building aesthetics.
- Appreciates the importance of quality workmanship and adherence to proper repair techniques in construction practices.

VI. Relevant Theoretical Background:

Spalling and delamination of plaster are common defects that occur due to a combination of physical, chemical, and environmental factors. Spalling refers to the breaking or flaking of plaster, often caused by internal stresses, corrosion of reinforcement, or moisture ingress, while delamination is the separation of plaster layers from the base surface due to poor bonding or trapped moisture. The main causes include prolonged exposure to moisture, corrosion of embedded reinforcement, thermal stress, poor workmanship, and the use of substandard materials. When moisture penetrates through cracks or porous surfaces, it can corrode steel reinforcement, and the expansion of rust exerts pressure that causes the surrounding plaster to crack and detach. Improper mix ratios, insufficient curing, and lack of bonding agents during initial plastering also contribute to weak adhesion and eventual failure.

From a materials science perspective, plaster is typically made from a mix of cement, sand, and water, with additives to enhance performance. For effective repairs, modern materials such as polymer-modified repair mortars and acrylic-based bonding agents are used to improve flexibility, adhesion, and water resistance. Rust removers or corrosion inhibitors are also essential to treat any exposed reinforcement and prevent further deterioration. The repair process involves systematic steps: identifying the extent of damage, removing delaminated plaster, treating corroded steel, applying bonding agents, and reapplying suitable repair mortar. Proper curing and protection with waterproof coatings ensure long-term durability.

The theoretical principles behind these materials and methods include adhesion theory, corrosion chemistry, and the hygroscopic behavior of cement-based materials. These theories guide the selection and application of materials to ensure structural integrity and durability. A sound understanding of these principles is crucial to addressing the root causes of plaster failure, choosing the correct repair approach, and ensuring the effectiveness and longevity of the remedial work.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	State Schedule of Rates (SSR)	Item rates	01	Per batch
2	Brochure of equipment's	Construction equipment's.	Required	Per batch
3	Labor charges and acts	GR about labour charges	Required	Per batch
4	Data base of materials	Standard materials	Required	Per batch

VIII. Precautions to be followed:

1. Ensure accurate and detailed observations during the site visit to capture all relevant information about the extent of damage, materials used, and environmental conditions.
2. Verify technical data and material specifications from reliable sources or site experts before including them in the report to maintain accuracy and credibility.

IX. Procedure:

1. Initiate the Visit:

- Define the purpose of the visit clearly (inspect plaster spalling/delamination).
- Coordinate timing and logistics with the site team.

2. Conduct Visual and Physical Examination

- Walk through the site systematically, observing plaster surfaces.
- Identify areas showing damage such as cracks, peeling, and hollow sounds.
- Note environmental conditions affecting the plaster (humidity, water leaks).

3. Collect Evidence and Record Data

- Take detailed notes on the type, location, and severity of damage.
- Capture high-quality photographs of affected areas for documentation.
- Gather information on existing plaster materials and any prior repair attempts.

4. Engage with Site Personnel

- Interview maintenance staff or contractors for insights on materials and techniques used.
- Clarify any uncertainties about past repairs or causes of damage.

5. Analyse Findings

- Review collected data to determine root causes (moisture, corrosion, poor workmanship).
- Match observed damage with material properties and environmental factors.

6. Research Suitable Repair Solutions

- Identify appropriate materials like bonding agents, repair mortars, and protective coatings.
- Select repair methods based on best industry practices and site-specific needs.

7. Compile the Visit Report

- Organize all information into sections: Observations, Causes, Materials Used, Repair Techniques, and Recommendations.
- Highlight practical significance to emphasize the importance of repair work.

8. Review and Submit

- Proofread and validate technical content for accuracy.
- Share the report with supervisors, clients, or stakeholders for feedback and implementation.

X. Observation and Calculations:

1. Site Name: ………………………………………………….
2. Name of contractor (if employed): ………………………………………………….
3. Location of site: ……………………………………………….
4. Date of visit: …………………………………………………

A. Site Observations

Sr. No	Location/ Member	Type of Damage Observed	Cause (Probable)	Severity	Remarks / Action Suggested

B. Materials Required for Repair

Sr. No.	Repair Activity	Material	Specification/Type	Purpose

C. Repair Techniques Recommended

Sr. No.	Repair Activity	Description	Remarks

XI. Result:

XII. Interpretation of results:

XIII. Conclusions:

XIV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What are the main causes of plaster spalling or delamination?
2. Why is a bonding agent necessary before applying new plaster?
3. How does polymer-modified mortar improve the durability of repaired plaster?
4. The site visit/video demonstrated the use of bonding agents, repair mortars, and protective coatings as essential materials for restoring areas affected by plaster spalling.
5. The repair technique shown included removing loose plaster, cleaning the substrate, applying a bonding coat, and finishing with a compatible repair mortar to ensure proper adhesion and durability.

Space for Answer

XV. References / Suggestions for further Reading:

- IS 15988:2013 – Guidelines for Repair and Rehabilitation of Reinforced Concrete Structures (Bureau of Indian Standards)
- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
- Concrete Technology" by M.S. Shetty.
- Maintenance and Repair of Civil Structures" by B.L. Gupta & Amit Gupta.
- CPWD Specifications and Schedule of Rates (SOR).
- PWD State Schedules of Rates.

XVI. Assessment Scheme:

Sr. No	Performance Indicators	Weightage (%)
A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
2	Installing the equipment and performing test	30%
B.	**Product related: 10 Marks**	**40%**
1	Analyzing the observations	5%
2	Interpretation of result	10%
3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	

Practical No: 15 **Prepare the visit report on repairing of roof slab/sanitary unit using any one technique to remove leakage.**

I. Practical Significance:

Repairing leakage in roof slabs or sanitary units using the cementitious waterproof coating technique is highly practical and effective. It provides a durable and seamless barrier against water penetration, preventing dampness, corrosion of reinforcement, and deterioration of concrete. This method enhances the life span of the structure, reduces maintenance costs, and ensures hygiene and safety in sanitary areas. Its ease of application and compatibility with existing surfaces make it suitable for both old and new construction, ensuring long-term waterproofing performance.

II. Industry/Employer expected outcome(s):

- Ability to identify causes and locations of leakage in roof slabs or sanitary units accurately.
- Skill to apply appropriate waterproofing materials and techniques effectively
- Understanding of quality control measures to ensure long-term durability and maintenance-free performance.

III. Course Level Learning Outcome (COs):

- CO 5 - Suggest the relevant method of repair to regain the strength of the given RCC component.

IV. Laboratory Learning Outcome (LLO):

- LLO 15.1-Undertake the repairing of leakage in the given sanitary unit.

V. Relevant Affective Domain Related Outcome(s):

- Develops a sense of responsibility toward maintaining structural safety and durability.
- Shows willingness to follow safety practices and quality standards during repair work.
- Demonstrates teamwork, discipline, and professional attitude while performing site activities.

VI. Relevant Theoretical Background:

Leakage in roof slabs or sanitary units generally occurs due to cracks, poor workmanship, improper slope, or deterioration of waterproofing layers. Theoretical understanding of waterproofing techniques, material properties, and causes of leakage is essential to select an appropriate repair method. Cementitious waterproofing, a commonly used technique, involves applying a polymer-modified cement slurry that forms a dense, impermeable coating over concrete surfaces. This layer prevents water ingress, protects reinforcement from corrosion, and enhances the structural life. Knowledge of material composition, surface preparation, and curing requirements is crucial to ensure effective and long-lasting leakage repair.

VII. Required resources/equipment:

Sr. No.	Particulars	Specification	Quantity	Remark
1	State Schedule of Rates (SSR)	Item rates	01	Per batch
2	Brochure of equipment's	Construction equipment's.	Required	Per batch
3	Labor charges and acts	GR about labour charges	Required	Per batch
4	Data base of materials	Standard materials	Required	Per batch

VIII. Precautions to be followed:

- Clean and dry the surface properly before applying the waterproofing material to ensure good adhesion.
- Maintain correct mixing ratio and apply the coating uniformly in thin layers.
- Protect the treated surface from rain or mechanical damage until proper curing is completed.

IX. Procedure:

1. **Identification of Problem Area:** Inspect the roof slab or sanitary unit to locate leakage points, cracks, or damp areas through visual observation and water testing.
2. **Surface Preparation:** Clean the affected area thoroughly by removing dust, loose plaster, or old waterproof coating. Ensure the surface is dry and sound.
3. **Crack Treatment:** Fill visible cracks or joints using polymer-modified mortar or suitable sealant to prevent further seepage.
4. **Application of Waterproofing Technique:** Apply the selected waterproofing method (e.g., cementitious coating, liquid membrane, or bituminous coating) in two or more layers as per the manufacturer's instructions.
5. **Curing and Testing:** Allow proper curing of the coating and perform a ponding or water test to check for any remaining leakage.
6. **Report Preparation:** Record site details, materials used, stepwise process, observations, and outcomes to prepare the final visit report.

X. Observation and Calculations:

1. Site Name: ……………………………………………….
2. Name of contractor (if employed): ……………………………………………….
3. Location of site: …………………………………………….
4. Date of visit: ……………………………………………….

A. Site Observations

Sr. No	Location/ Member	Particulars of damage observed	Suggested repairing technique

XI. Result:

XII. Interpretation of results:

XIII. Conclusions:

XIV. Practical Related Questions:

Note: Below given are few sample questions for reference. Teachers must design more such questions so as to ensure the achievement of identified CO.

1. What steps are necessary to prepare the surface before applying a waterproofing coating?
2. How do polymer-modified mortars improve the durability of repaired roof slabs or sanitary units?
3. How can you test the effectiveness of the applied waterproofing technique on site?
4. What surface preparation steps were observed during the visit/demo before applying the chosen leakage-repair technique (e.g., waterproof coating, injection grouting, or membrane application)?
5. Which materials and tools were used on-site to ensure the leakage was effectively sealed, and how was the effectiveness of the repair method verified?

Space for Answer

XV. References / Suggestions for further Reading:

- IS 15988:2013 – Guidelines for Repair and Rehabilitation of Reinforced Concrete Structures (Bureau of Indian Standards)
- IS 456:2000 – Code of Practice for Plain and Reinforced Concrete
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XVI. Assessment Scheme:

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A.	**Process related: 15 Marks**	**60%**
1	Safety precautions followed	30%
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1	Analyzing the observations	5%
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3	Conclusions and Recommendations.	10%
4	Answers to practical related questions.	10%
5	Submission of report in time.	5%
C.	**Total marks (25 marks)**	**100%**

Marks Obtained			**Dated sign of Teacher**
Process Related (15)	**Product Related (10)**	**Total (25)**	