AN EXPERIMENTAL CASE STUDY TO CHECK THE STABILITY OF RCC BRIDGE BY VARIOUS METHODS

Omprakash Gehlot[1], Er. Mahendra Saini[2]

[1]M.Tech Scholar, Regional College for Education Research & Technology, Jaipur, Rajasthan, India
Rajasthan Technical University, Kota, Rajasthan, India
[2]Assistant Professor, Regional College for Education Research & Technology Jaipur, Rajasthan, India
Rajasthan Technical University, Kota, Rajasthan, India

Abstract- Bridge load trying out is a essential method to evaluate the in-situ overall performance of superstructures and to verify assumptions made in the design segment. The gift take a look at turned into carried out at the superstructure minor bridge span (A1–W1) at Ch.-104 800 for the Beawar–Gomti Section Project on NH-eight, Rajasthan. The proof load check was completed with a complete carried out load of 128 MT, equal to the simulated IRC-designed loading with effect, and retained for twenty-four hours. Deflections have been measured with correction for temperature outcomes, and the results were evaluated in opposition to IRC SP fifty one-2015, IS 14893:2021, IS 516:2018/2021, and different applicable codes.

The percent recuperation of deflection become observed to be greater than 85%, which exceeds the minimal recuperation limits prescribed via IRC SP 51-2015 for all styles of bridges, confirming the adequacy of elastic conduct. The maximum measured deflection of one.342 mm become appreciably decrease than the theoretical permissible restriction of 4.5 mm beneath 70R loading, indicating high stiffness and serviceability. Crack width measurements remained below 0.30 mm, that is within the attractiveness criteria for mild exposure situations.Complementary assessments further verified the integrity and electricity of the shape. Pile integrity exams discovered homogeneous first-rate with no seen bulges or defects, and a pile duration of about 25 m, gratifying IS 14893:2021 necessities. Compressive electricity exams of cubes handed M-50 MPa, with appropriate versions, even as middle assessments confirmed an equivalent electricity above 0.85 fck. Non-negative trying out the usage of the rebound hammer indicated quality consequences within ±25% electricity correlation, and ultrasonic pulse velocity measurements (>four.0 km/s) graded the concrete excellent as right to first-rate. Depth of carbonation was measured among 0.50 mm and 4.Five mm, nicely within the safe limits prescribed by means of IS standards. The trying out confirms the structural adequacy, reliability, and serviceability of the bridge span, thereby validating the design assumptions and ensuring long-time period protection of the structure.

Keywords: Bridge load testing, proof load, deflection recovery, crack width, rebound hammer, ultrasonic pulse velocity, and carbonation depth.

I. INTRODUCTION

Bridge load trying out is a critical approach for comparing the safety, overall performance, and serviceability of bridges below actual visitors or managed loading situations. In India, the Indian Roads

Congress (IRC) has standardized the techniques thru IRC: SP: 51 – "Guidelines for Load Testing of Bridges" (2015). These hints offer a systematic framework for conducting static and dynamic load tests, protecting components including loading preparations, instrumentation, deflection and pressure measurements, crack monitoring, and standards for acceptance.

Load testing serves primary functions:

1. Proof Load Test – Verifies whether a newly built or rehabilitated bridge meets the design necessities.

2. Diagnostic Load Test – Evaluates the actual conduct of an present or deteriorated bridge to determine residual life and want for strengthening.

With the increasing age of infrastructure in India and growing site visitors demands, load checking out has won prominence as a reliable device for selection-making regarding bridge safety, retrofitting, or substitute. IRC: SP:51 has aligned Indian practices with global requirements, ensuring bridges are tested scientifically earlier than being declared safe for public use.

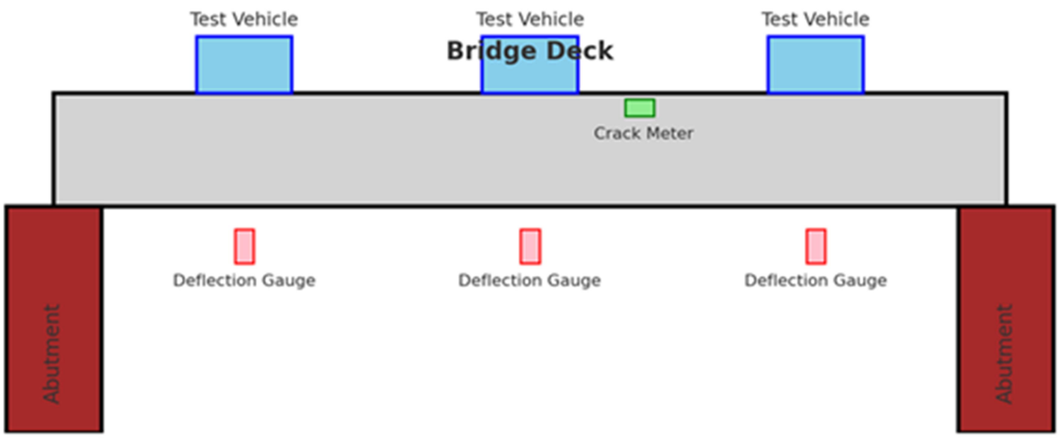


Figure1. Custom schematic diagram of bridge load testing as per **IRC SP:51**.
It shows:

- **Test Vehicles** placed on the bridge deck
- **Deflection Gauges** installed below the deck at key positions
- **Crack Meter** on the deck surface
- **Abutments/Supports** at both ends

II. LITERATURE REVIEW ON BRIDGE LOAD TESTING AS PER IRC SP 51

Bridge Load Testing

2025 – Municipal Practices: Ahmedabad Municipal Corporation mandated inspection and cargo checking out of all bridges older than 15 years after the Gambhira crumble. Both unfavourable and non-unfavorable strategies had been adopted, aligning with IRC SP 51 (2015) tips. This reflects a shift in the direction of records-pushed safety tests, such as deflection, crack, and vibration tracking (Ahmedabad Municipal Corporation, 2025).

2024- Agarakar, E., et.al (2024).Aging infrastructure in educational institutions requires systematic structural audits and rehabilitation to ensure safety and sustainability. This review highlights the audit and rehabilitation efforts undertaken for old buildings at BDCE campus. It discusses methodologies such as non-destructive testing, structural health monitoring, and computer-aided modeling, along with challenges like material deterioration, architectural constraints, and code compliance. The study emphasizes interdisciplinary collaboration and outlines rehabilitation strategies including retrofitting, innovative materials, and sustainable practices. Case studies from the BDCE campus demonstrate practical applications, while the article also evaluates the economic, environmental, and cultural benefits of rehabilitation compared to new construction.

2023- Desai, S.et.al (2023)Structural audits in civil engineering help ensure the safety and longevity of buildings by assessing deterioration such as cracks, rust, and aging signs. Using non-destructive testing (NDT) methods—like rebound hammer or ultrasonic tests—and adhering to Indian Standard (IS) codal provisions, engineers can evaluate a building's current condition. Regular audits every five years, along with consistent maintenance (addressing leaks, moisture, and environmental damage), can extend a structure's service life in a cost-effective way. Neglecting maintenance, especially for buildings older than 30 years, can pose severe risks to occupants and neighboring structures.

2022 –Karthik, Sharma, and Akbar (2022) confirmed that modern heavy vehicles (as much as 3850 kN) call for revisions in IRC SP 51 take a look at protocols. Their "Intensity Factor" highlights span-dependent load effects, stressing that modern-day codal practices may additionally underestimate actual area demands.

2022- Woyciechowski, P,et.al (2022). Concrete carbonation is influenced by multiple factors, including material heterogeneity, which leads to an irregular carbonation front. This article reviews standard methods used to measure carbonation depth and introduces an alternative technique that evaluates the ratio of carbonated to non-carbonated areas to calculate average carbonation depth. Comparative analysis shows differences between conventional approaches and the proposed off-standard method.

2022 –Patil et al. (2022) proven SP fifty one processes on a 17.2 m span bridge. Field outcomes confirmed deflections and cracks within codal limits, proving the reliability of SP 51 while carried out fastidiously.

2020 –Shan et al. (2020) emphasized diagnostic testing as part of lifecycle control. They recommended superior equipment (e.G., DIC, MEMS sensors, laser systems) and integration with FE fashions and SHM, showing where Indian practice can evolve.

2018 - Agarwal, Y.et.al (2018,)In recent years, several structural failures of buildings and bridges have highlighted the importance of structural audits. This study reviews key factors involved in auditing different types of structures. The findings indicate that although structural audits are generally conducted by civil engineers, the processes and evaluation parameters differ depending on the type and scale of the structure. These variations influence both the assessment and the redevelopment strategies for superstructures.

2017 - Parmar, et.al. (2017). Non-destructive testing (NDT) is a method used to evaluate construction materials and structural members without causing permanent damage. While commonly applied to concrete for assessing compressive strength and protecting embedded steel reinforcement, NDT techniques can also be effectively applied to other building materials. This study presents a case analysis of rebound hammer testing on concrete and structural elements, highlighting its role in structural evaluation.

Codal Framework: IRC SP fifty one (2015) sets acceptance limits—deflections ≤a hundred twenty five% of theoretical, residual deflection ≤20%, crack widths ≤zero.25 mm (RCC) and ≤zero.1 mm (PSC). Complementary codes like IRC SP 37 assist analytical scores and potential assessment.

2013- Varma, S. J.et.al (2013). Pile foundations, essential for large civil structures, can develop defects such as cracks in precast piles or irregularities like necks and bulbs in cast in situ piles. These flaws reduce load-bearing capacity and compromise structural safety. Pile Integrity Testing (PIT), a non-destructive method using an accelerometer, hammer, and data acquisition unit, helps evaluate pile length and detect defects by analyzing wave reflections. This study applies PIT to assess damage mechanics in cast in situ pile foundations.

III. METHODOLOGY

3.1 To conduct a bridge load test as per IRC: SP-51:2015.

Sequence of Loading & Unloading:

- Test load is applied in 3 Stage as 33.33%, 66.66%, and 100.00% of the test load. The total test load was maintained for 24 hours, and measurements of deflections & temperature were recorded hourly.
- Unloading is done in the same reverse sequence, and deflections & temperature are recorded hourly for 24 hours.
- Magnitude and the position of the live load generating a maximum bending moment in the span as mentioned in the load testing arrangement drawing. The load test will be conducted using Test Vehicle as mentioned in the load testing arrangement drawing.

Table 1.

	Stage	**Test Vehicle**	**Load in MT**
Loading Cycle	Stage I	Mobilize Vehicle V-1	36MT
	Stage II	Mobilize Vehicle V-1 &V-2	36+46 = 82MT
	Stage III	Mobilize Vehicle V-1 &V-2 & V-3	36+46+46=128MT
100% Live Load on span and retained for 24 hrs. on the structure			
Unloading Cycle	Stage I	Mobilize Vehicle V-3	46MT
	Stage II	Mobilize Vehicle V-3 &V-2	46+46 = 92MT
	Stage III	Mobilize Vehicle V-3, V-2 & V-1	46+46+36 = 128MT
No Live Load on span and retained for minimum 24 hrs.			

3.1.1 PROCEDURE:

The decided on span (A1–W2) was whitewashed and punctiliously inspected for cracks previous to testing. Dial Gauges (1–five) with simple glass plates (50×50×five mm) had been constant under the beam using epoxy to make certain continuous spindle contact. Thermometers and dial gauges had been mounted with magnetic bases to file each deflection and temperature, enabling correction for thermal outcomes.

Deflection and temperature readings were taken at 1-hour intervals throughout the test. The loading sequence become implemented incrementally at 33.33%, sixty six.Sixty six%, and 100%, with each stage maintained until deflection stabilized (minimum 1 hour). The 100% load become sustained for 24 hours, with hourly readings recorded. Unloading became performed in reverse order (100%, sixty six.Sixty six%, 33.33%), additionally with hourly tracking, observed by using a 24-hour commentary length after entire unloading.

According to IRC SP 51 the percentage recovery shall be calculated for values of deflection. The percentage recovery is calculated at 24 hours after removal of load, the analysis is carried out after effecting temperature correction and bearing displacement correction, and total recovery is calculated as follows:

Initial value- deflection before commencement of loading = R1

Deflection at one hour, after placement of 100% test load = R2

Deflection at 24 hours after placement of 100% test load = R3

Deflection measurements immediately after removal of test load = R4

Deflection measurements at 24 hours after removal of test load = R5

Total deflection = R3 - R1

Total recovery of deflection after 24 hours after removal of test load = R3 – R5

Table 2.

Description	**Deflection at Span DG-1**	**Deflection at Span DG-2**	**Deflection at Span DG-3**	**Deflection at Span DG-4**	**Deflection at Span DG-5**
Total Deflection **(R3-R1)**	1.335	1.258	0.866	1.135	1.342
Total Recovery 24 Hours after removal of test load **(R3-R5)**	1.274	1.194	0.844	1.066	1.327
Percentage of Recovery of Deflection at 24 hours after removal of test load **(R3-R5)/(R3-R1) x 100**	95.43	94.91	97.46	93.92	98.88

3.2 Piles Integrity Test as per IS: 14893:2021.

Stress wave propagation tests using a small impact hammer and accelerometer were conducted on **6 selected piles** of the bridge site. The piles, **1.2 m in diameter and up to 25 m deep**, support both piers and abutments. One pile from each pier group (4 piles) and one pile from each abutment group (6 piles, two abutments) were tested to assess **structural integrity**. Stress waves reflected from the pile toe and any discontinuities were recorded for analysis.

This test is helpful to find the actual length of the pile under the foundation & find out the quality of the piles by the travelling stress wave in the pile.

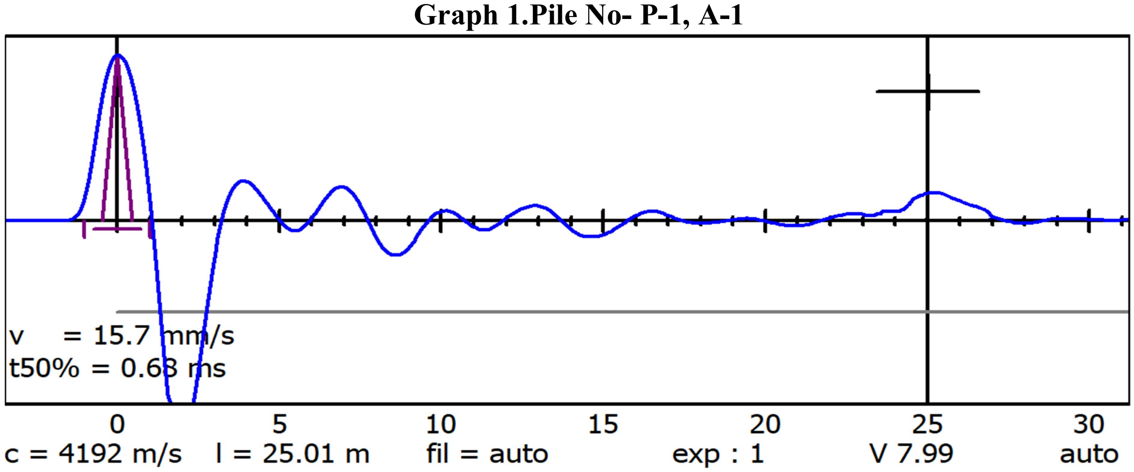
IV. RESULT & CALCULATION

Table 3.

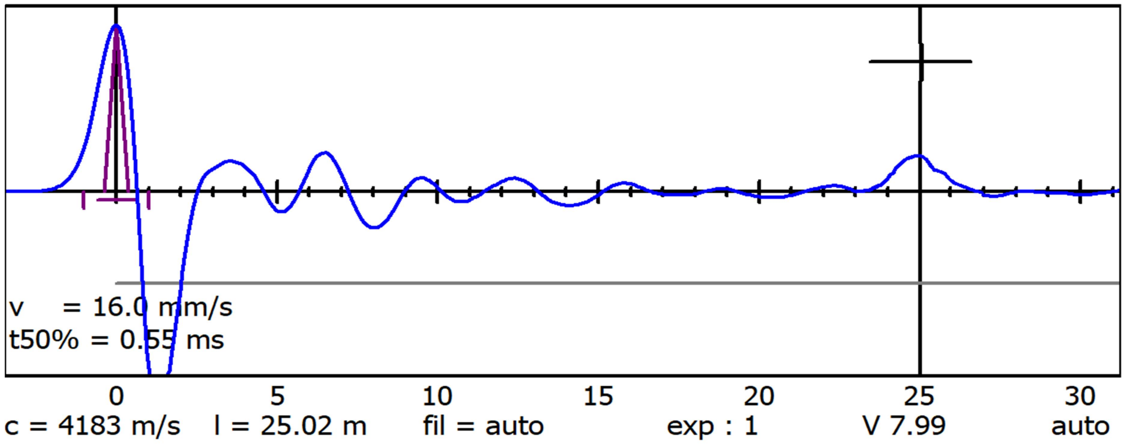
Pile Detail	Toe Response	Measured Length of Pile (m)	Wave Speed (m/sec)	Shaft Cross-Section (From test level)	Pile Integrity
P-1, A1	Evident	25.01	4192	Fairly uniform pile shaft	OK
P-2, A1	Evident	25.02	4183	Fairly uniform pile shaft	OK
,P-3, A1	Evident	25.03	4155	Fairly uniform pile shaft	OK
P-4, A1	Evident	25	4142	Fairly uniform pile shaft	OK
P-5, A1	Evident	25	4197	Fairly uniform pile shaft	OK
P-6, A1	Evident	24.98	4178	Fairly uniform pile shaft	OK

GRAPHS

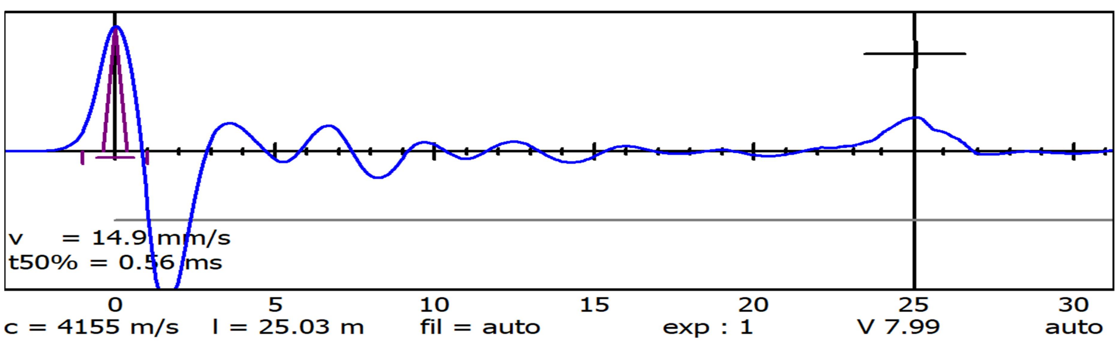
Graph 1.Pile No- P-1, A-1



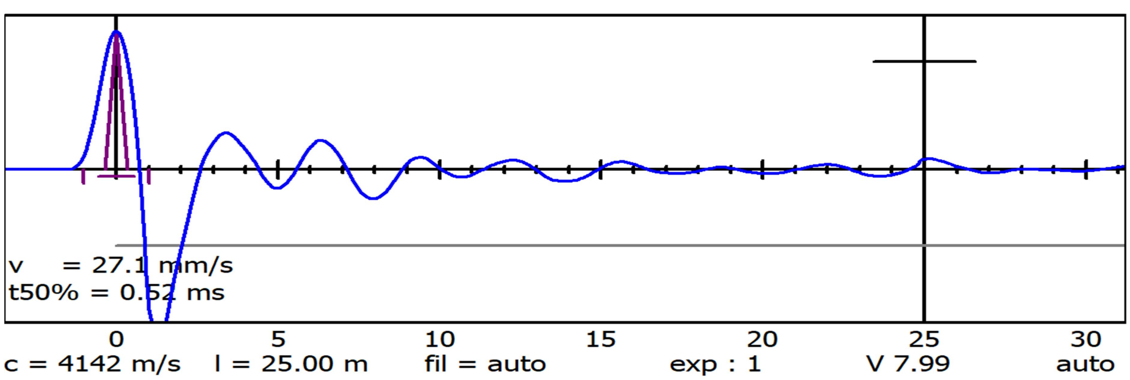
Graph 2.Pile No- P-2, A-1



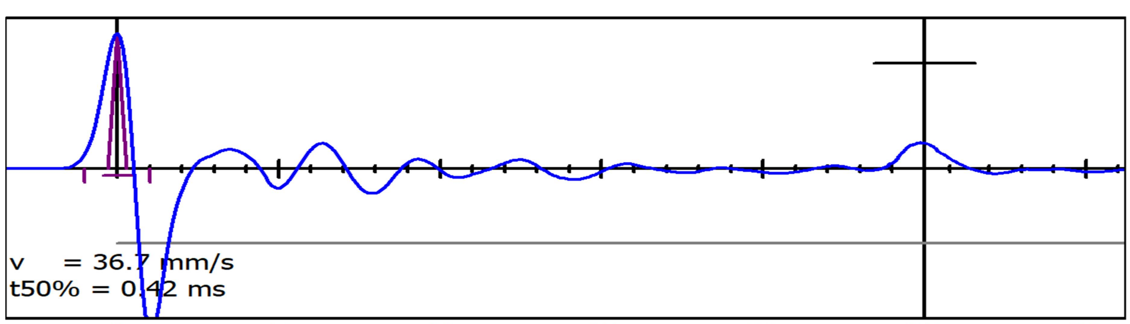
Graph 3.Pile No- P-3, A-1



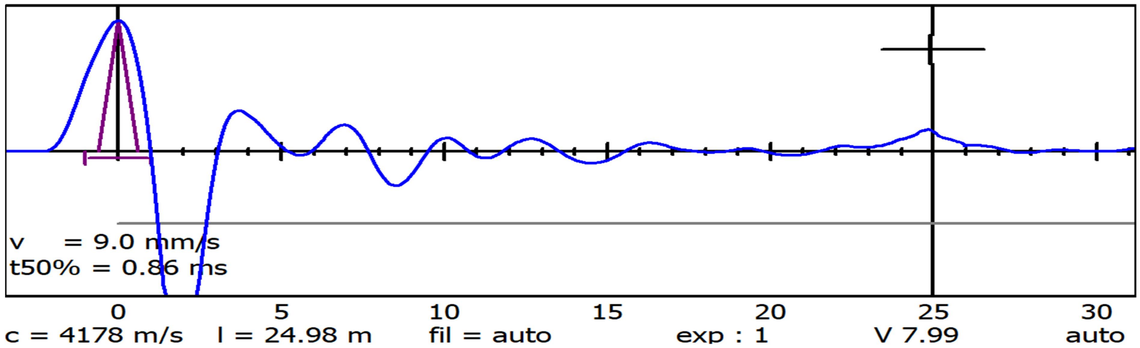
Graph 4.Pile No- P-4, A-1



Graph 5. Pile No- P-5, A-1



Graph 6.Pile No- P-6, A-1



4.1 Compressive Strength Test of Hardened Concrete as per IS: 516 (Part 1/Sec 1): 2021.

Preparation and Positioning of Specimens

Cube specimens had been taken out of water, wiped to put off excess moisture, and their dimensions (±0.2 mm) and weight had been recorded. Testing became carried out inside 2 hours of removal from curing, retaining specimens blanketed with wet fabric to keep away from drying. The CTM platens and specimen surfaces were wiped clean earlier than trying out. Load changed into carried out in CTM progressively at 14 N/mm²/min with out surprise, and the maximum load turned into recorded for strength calculation.

4.1.1 CALCULATION OF TEST DATA:

Cube specimen compressive strength is given by the following formula:

fc = F/Ac

Where

fc = compressive strength, in N/mm^2 (Mpa)

F = failure maximum load, in Newton (N)

Ac = Average cross-section area, in mm^2

Table 4.

ID Mark	Average Sectional Dimensions (mm × mm)	Cross Sectional Area (mm^2)	Maximum Load (N)	Compressive Strength (MPa)	Avg. Comp. Strength (MPa)	Weights (g)
1	150.02 x 150.06	22512.00	1274.2x 10^3	56.6	56.2	8492
2	150.04 x 150.06	22515.00	1256.8 x 10^3	55.8		8488
3	150.08 x 150.06	22521.00	1267.4 x 10^3	56.3		8522

3.2 Core specimen compressive strength is calculated by following:

The measured compressive strength of the core specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest N/mm^2

Correction factor for core diameter (less than 100mm) as given below:

Diameter of core (mm)	Correction Factor
75 ± 5 mm	1.03
<70 mm	1.06

Correction factor according to the l/d ratio of core specimen after capping shall be obtained from the following equation

$F = 0.11N + 0.78$

Where

F = correction factor

N = length/diameter ratio

The equivalent cube strength of the concrete shall be determined by multiplying the corrected cylinder strength by 5/4.

. **Table 5.**

ID Mark	Length of Core (mm)	Dia. of Core (mm)	Area (mm^2)	Weight (g)	Max. Load (N)	Comp. Strength (MPa)	L/D Ratio	L/D Ratio C.F.	Corrected Comp. Strength for L/D Ration (MPa	Equivalent Cube Comp. Strength (MPa)
1	239.10	142.89	16035.91	8392	724.6×10^3	45.2	1.67	0.964	43.6	54.5
2	228.90	143.57	16188.90	8402	696.0×10^3	43.0	1.59	0.955	41.1	51.4
3	230.60	144.90	16831.64	8468	711.0×10^3	42.2	1.59	0.955	40.3	50.4

4.2 To conduct NDT test by Ultrasonic Pulse Velocity as per IS: 516 (Part 5/Sec 1): 2018.

4.2.1 Scope: This method uses investigation for hardened concrete. Concrete quality, like density, homogeneity, and uniformity, is good in this case; the higher velocity is obtained & the path length is shorter. In the case of poorer quality, lower velocities are obtained

4.2.2 PROCEDURE: Mark a 300 x 300 mm grid on the structure member & take the path length L in mm. Place the UPV transducer on the surface of the concrete member, after traversing a known path length in the concrete, the pulse of vibrations is converted into an electrical signal by the second transducer held in contact with the other surface of the concrete member, and an electronic timing circuit enables the transit time (T). The pulse velocity (V) is given by:

$$V = L/T \text{ in Km/sec.}$$

4.2.3 POSITIONING OF TRANSDUCERS

Both transducers put on opposite face are called Direct Transmission.

Both transducers put on adjacent face are called Semi-direct transmission.

Both transducers are place on same face is called Indirect Transmission.

Table 6.

S. No	Location	Direction of Transmis sion	Path Length (L)	Time (T)	Average Pulse Velocity (km/sec)	Concrete Quality Grading
1.	RHS Wall (W1)	Indirect	500	118.9	4.2+0.5 = 4.7	Excellent
2.	RHS A1 Wall	Indirect	500	125.1	4.0+0.5 = 4.5	Good
3.	RHS 1st Span Slab	Indirect	500	121.4	4.1+0.5 = 4.6	Excellent
4.	RHS A1 Wall	Indirect	500	131.5	3.8+0.5 = 4.3	Good
5.	RHS 3rd Span Slab	Indirect	500	124.9	4.0+0.5 = 4.5	Good
6.	LHS Wall (W1)	Indirect	500	128	3.9+0.5 = 4.4	Good
7.	LHS A1	Indirect	500	128.6	3.9+0.5 = 4.4	Good
8.	RHS 2nd Span Slab	Indirect	500	121.9	4.1+0.5 = 4.6	Excellent
9.	RHS Wall-1 (W1)	Indirect	500	129.0	3.9+0.5 = 4.4	Good
10.	Girder G-2	Indirect	500	113.6	4.4+0.5 = 4.9	Excellent
11.	Girder G-1	Indirect	500	118.9	4.2+0.5 = 4.7	Excellent
12.	Cross Girder	Indirect	500	122.5	4.1+0.5 = 4.6	Excellent
13.	Slab between G-1 to G-2	Indirect	500	122.9	4.1+0.5 = 4.6	Excellent
14.	Pier P-1 RHS	Indirect	500	126.7	3.9+0.5 = 4.4	Good
15.	Pier P-2 RHS	Indirect	500	124.9	4.0+0.5 = 4.5	Good
16.	P-1 Pier Cap RHS	Indirect	500	131.4	3.8+0.5 = 4.3	Good
17.	P-2 Pier Cap RHS	Indirect	500	124.4	4.0+0.5 = 4.5	Good
18.	Horizontal	Indirect	500	139.3	3.6+0.5 = 4.1	Good

4.3 To conduct NDT test by rebound hammer for strength check hardened concrete as per IS: 516 (Part 5/Sec 4): 2020.

4.3.1 Scope: The rebound hammer is a convenient process for estimating hardened concrete strength. A rebound hammer is used to determine the rebound number of hardened concrete using a spring-driven steel hammer. It is an alternative for the determination of compressive strength of concrete. This test is used to assess the uniformity of concrete quality.

4.3.2 DIRECTION OF TESITING: Horizontal, Vertical, Vertically Upwards & Vertically Downwards

4.3.3 RESULT& CALCULATION

Table 7.

S. No.	Location	Direction	Average Rebound Index Value	Compressive Strength (Mpa)

S. No.	Location	Direction	Average Rebound Index Value	Compressive Strength (Mpa)
1.	RHS Wall (W1)	Horizontal	42	46
2.	RHS A1 Wall	Horizontal	42	46
3.	RHS 1st Span Slab	Vertical Upward	46	45
4.	RHS A1 Wall	Horizontal	42	46
5.	RHS 3rd Span Slab	Vertical Upward	48	49
6.	LHS Wall (W1)	Horizontal	39	40
7.	LHS A1	Horizontal	40	42
8.	RHS 2nd Span Slab	Vertical Upward	44	42
9.	RHS Wall-1 (W1)	Horizontal	41	44
10.	Girder G-2	Horizontal	55	70
11.	Girder G-1	Horizontal	55	70
12.	Cross Girder	Horizontal	53	66
13.	Slab between G-1 to G-2	Vertical Upward	54	68
14.	Pier P-1 RHS	Horizontal	42	46
15.	Pier P-2 RHS	Horizontal	40	42
16.	P-1 Pier Cap RHS	Horizontal	46	53
17.	P-2 Pier Cap RHS	Horizontal	42	46
18.	Abutment	Horizontal	41	44

4.4 To conduct NDT test by Depth of Carbonation as per IS: 516 (Part 5/Sec 3): 2021.

4.4.1 Scope: The Carbonation test of concrete is determining the depth of carbonation, a process where carbon dioxide present in the atmosphere penetrates the concrete structure and reacts with calcium hydroxide and its components. This process is reducing alkalinity and potentially causing corrosion of steel reinforcement

4.4.2 PROCEDURE: The depth of the carbonation test is conducted on a freshly exposed concrete surface, a freshly broken surface of concrete,, and an extracted core sample from a concrete structure. After breaking the concrete surface, it should immediately be cleared of dust and loose particles. Indicator solution is sprayed or applied to the exposed concrete surface; uncarbonated concrete is still alkaline and gives a dark pink color (magenta).

4.4.3 RESULTS

Table 8.

Sr. No.	Location of Structure	Carbonation Depth (mm)
1.	Pier P-1 RHS	1.5
2.	Pier P-2 RHS	0.5
3.	P-1 Pier Cap RHS	2.0
4.	RHS Wall (W1)	3.0
5.	RHS A1 Wall	4.5
6.	RHS 1st Span Slab	2.5
7.	Girder G-1	0
8.	Cross Girder	0
9.	Abutment	3.1

4.5 Summary of Results

1) **Criteria – I:** As per IRC SP 51-2015 clause no. 6.8.2, the percentage recovery of deflection for various types of bridges after retention of the load for 24 hours shall be:

Table 9.

Sr. No.	Types of Bridges	Minimum Percentage Recovery of Deflection at 24 hours after Removal of Test Load
1.	Reinforced Concrete Bridge	75
2.	Prestressed Concrete Bridge	85
3.	Steel Bridge	85
4.	Composite Bridge	75

➢ The bridge load test was carried out on the Superstructure **Minor Bridge Span (A1-W1) at Ch.-104+800 for the Beawar-Gomti Section Project on NH-8 Rajasthan.** At the time of the test, the load was **128 MT**, equivalent to the simulated IRC-designed load with impact for 24 hrs. On the superstructure, with corrected deflection measurements for temperature effect, the percentage recovery of deflection of all dial gauges on removal of load obtained more than **85%**, which is within the acceptance criteria of IRC SP 51-2015.

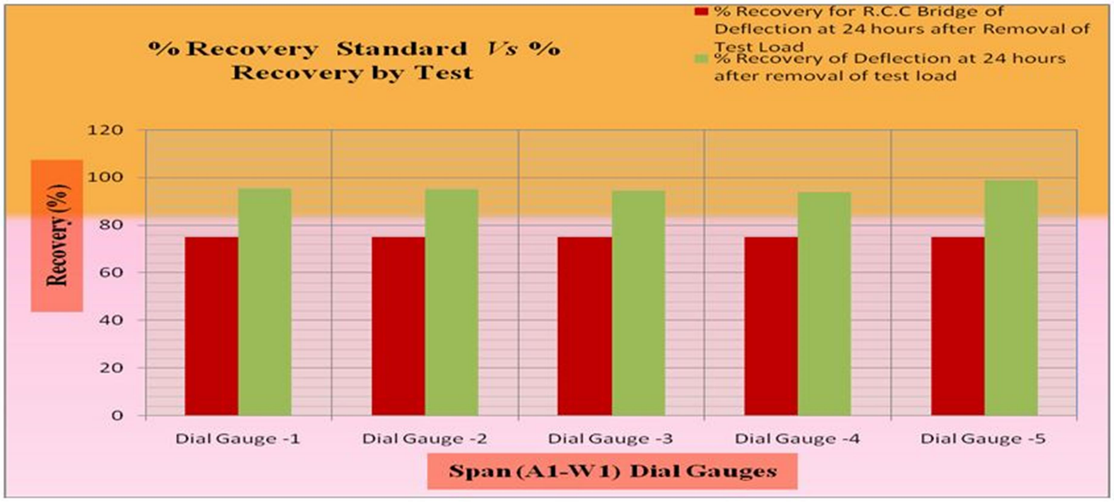


Figure 2. % Recovery Standard vs. % Recovery Test

Table 10.

Sr. No.	Location at Span (A1-W1)	Maximum Theoretical Deflection for 70R Loading including Impact Factor (in mm)	Measured Actual Maximum Deflection (in mm)
1.	Dial Gauge -1	4.500	1.335
2.	Dial Gauge -2	4.500	1.258
3.	Dial Gauge -3	4.500	0.866
4.	Dial Gauge -4	4.500	1.135
5.	Dial Gauge -5	4.500	1.342

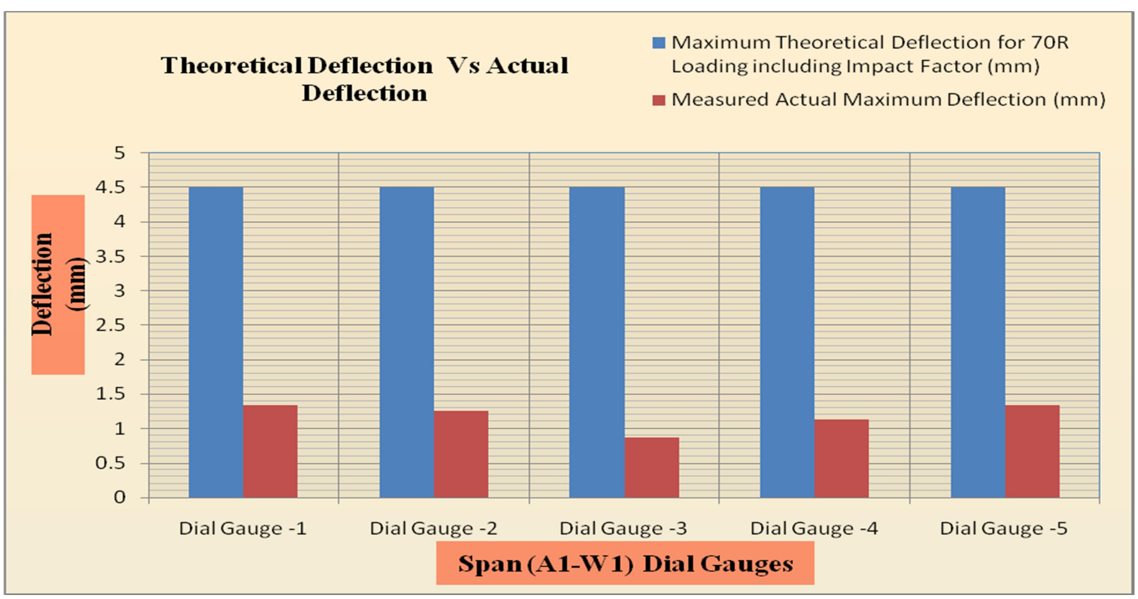


Figure 3. Theoretical vs. Actual Deflection

- The maximum deflection of the tested bridge is observed to be **1.342 mm,** which is less than the permissible deflection as per design & within the acceptance criteria.

- As per clause no. 6.8.2, the structure shall not show any cracks more than 0.3 mm for moderate exposure and 0.20 mm for severe conditions of exposure, spalling, or deflections that are incompatible with safety requirements.

- Observed crack width in the tested bridge is less than 0.30, which is within the acceptance criteria.

- The superstructure load test is satisfactory for structural behavior adequacy.

2) **Criteria – II:** As per IS: 14893:2021 clause no. 6.0, the assessment of structural integrity is as following

- Tested piles show a clear toe response without any minor defects.
- Tested piles do not show any clear defects
- Piles do not show large bulges.
- All pile length is found to be approx 25.0 m & the pile is homogeneous in quality.
- The foundation pile integrity test is found satisfactory.

3) **Criteria – III:** As per IS: 516 (par 1/Sec. 1): 2021 clause no. 3.6, the assessment of cube compressive strength is as following:

- The average of three cubes shall be taken, & individual variation is not more than ± 15% of the average value.
- The actual dimensions of cube specimen variation are not more than 0.20 mm as per IS: 10086:2021.
- Compressive strength of cube specimens was found to be >M-50 MPa it ok.

4) **Criteria – IV:** As per IS: 516 (par 4): 2018 Annex B clause no. B-2, the acceptance criteria of the core test are given below:

- The average equivalent cube strength of core specimens is more than $0.85f_{ck}$, and the individual equivalent cube strength of core specimens is not less than $0.75f_{ck}$.
- The Equivalent cube strength of core specimens is found to be >M-50 Mpa, it is more than $0.85f_{ck}$, so the structure strength is found to be ok.

5) **Criteria – V:** As per IS: 516 (Part 5/Sec. 4) 2020 clause no. 8.1, the interpretation of Rebound Hammer Test is following:

- The estimation of the strength of a concrete structure by the rebound hammer method is up to ± 25% depending upon the correlation between the rebound index and the compressive strength curve.
- Rebound hammer results was found to be satisfactory, ok.

6) **Criteria – VI:** As per IS: 516 (Part 5/Sec. 1) 2018 clause no. 2.5.2 Table 1, the velocity criterion for concrete quality grading is as follows:

Sr. No.	**Average Value of Pulse Velocity by Cross Probing km/s**	**Concrete Quality Grading**
a) For (≤M25 Grade of concrete)		

1	Below 3.5	Doubtful
2	3.5-4.5	Good
3	Above 4.5	Excellent
ii) For (>25 Grade of concrete)		
1	Below 3.5	Doubtful
2	3.5-4.5	Good
3	Above 4.5	Excellent

- A test is conducted on said bridge, and results are found the average value of pulse velocity by cross probing was above 4.0, and a concrete quality grade of good or excellent is obtained.
- No doubtful reading found by the testing.
- The ultrasonic pulse velocity test was found satisfactory for the structure.

7) **Criteria – VII:** As per IS: 516 (Part 5/Sec 3) 2021, the depth of carbonation is as follows:

- Mean carbonation the depth of concrete in the structural member was found to be between 0.50 mm to 4.5 mm it's satisfactory for the structure.

V. Conclusion

The comprehensive testing and assessment of the RCC minor bridge superstructure at span (A1–W1) on the Beawar–Gomti Section of NH-8, Rajasthan, confirm its structural adequacy and serviceability. The evidence load test, carried out with 128 MT loading as according to IRC layout standards, confirmed terrific overall performance with deflection recovery exceeding eighty five%, a ways above the minimum requirements of IRC SP fifty one-2015. The most measured deflection of one.342 mm was appreciably lower than the theoretical permissible deflection of four.5 mm, while discovered crack widths remained under zero.30 mm, meeting the protection standards for mild publicity situations.

Foundation integrity become demonstrated thru pile testing, which confirmed homogeneous pleasant without bulges or defects, gratifying IS:14893:2021 necessities. Material power evaluation through dice compressive strength, core energy, and rebound hammer checks indicated compressive strength more than M-50 MPa and in the targeted popularity criteria. Ultrasonic pulse pace testing confirmed the concrete pleasant as desirable to tremendous, with no dubious readings, even as carbonation intensity remained between 0.50 mm and four.5 mm, indicating long-term durability of the structure.

Overall, the bridge superstructure and foundation met all seven recognition criteria set forth in IRC and IS codes, confirming structural integrity, durability, and cargo-sporting ability. The outcomes validate the layout assumptions and demonstrate that the bridge is structurally safe, serviceable, and ready for endured use in its meant carrier conditions.

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