Disaster Management in Bridge Collapse: Case Studies on Bridge Failures in India. Lessons from the Taratala Flyover Incident, Kolkata

Gautam Bondyopadhyay

Civil Engineering, OmDayal Group of Institutions, India

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Abstract: Bridge collapses are catastrophic infrastructure failures, leading to loss of life, disruption of mobility, and erosion of public trust. This paper analyses four major Indian bridge collapses (2013–2025) — Ultadanga, Talkies, Taratala (Majerhat), and Gambhira — using a Case–Cause–Lesson framework. A comparative study of Majerhat (2018) and Gambhira (2025) is presented to highlight recurring weaknesses in design, construction, maintenance, governance and have revealed severe deficiencies in structural health monitoring, inspection protocols, and disaster preparedness. This paper integrates case-based forensic analysis with international benchmarking to identify systemic gaps in bridge safety management. Using a mixed qualitative–quantitative framework, the study examines causes, consequences, and institutional responses to recent bridge failures. A comparative overview of international best practices (Japan, UK, USA) informs a roadmap for implementing IoT-based Bridge Health Monitoring (BHM) and Digital Twin frameworks in Indian conditions. Results highlight the urgent need for integrated governance, transparent maintenance systems, and community-focused disaster management protocols.

Keywords: Bridge collapse, Disaster management, Taratala flyover, Structural health monitoring, SOP

A. Reasons for Bridge Collapse

- Old Bridges: Often vulnerable to deterioration, age-related wear and tear, and accumulated damage from various factors like corrosion and stress.
- New Bridges: Can fail due to design errors, poor construction quality, sub-standard materials, inadequate supervision, or unexpected environmental loads that were not considered during design.
- Ageing structures – deterioration, corrosion, and fatigue in old bridges.
- Design & construction flaws – errors, sub-standard materials, or poor workmanship.
- Inadequate maintenance – lack of inspection and preventive care.
- Natural disasters – floods, earthquakes, landslides, and scour around foundations.
- Extreme weather – climate change-driven storms and flood debris impact.
- Accidents & impacts – collisions by vehicles, ships, or trains.
- Construction phase failures – collapses during erection due to poor planning or sequencing.
- Material deficiencies – low-quality or defective materials.
- Fires & explosions – fuel tanker accidents or flammable structures.
- Combined factors – multiple stresses acting together, leading to sudden failure.

B. Disaster Management & Actions

- Early Detection: Conduct regular and comprehensive bridge health assessments to identify potential structural weaknesses before they become critical.
- Inspection Protocols: Establish standardized protocols for visual inspections and non-destructive testing to evaluate a bridge's condition accurately.
- Rehabilitation: Implement timely repair and rehabilitation work to address identified issues, such as corrosion or structural deficiencies.
- Emergency Response: Develop clear procedures for responding to incidents like bridge damage, including rescue, traffic management, and temporary structural support.

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I. Introduction

India's ageing bridge inventory—estimated at over 150,000 structures—faces growing stress from overloading, deferred maintenance, and climatic extremes. The 2018 Majerhat Flyover collapse in Kolkata and the 2025 Gambhira Bridge collapse in Gujarat demonstrate not only technical degradation but also institutional and governance failures.

While bridge failure analyses are often confined to engineering reports, disaster management demands a holistic view encompassing technical, administrative, and emergency response dimensions. International experiences—such as the I-35W Bridge collapse (USA, 2007) and Genoa's Morandi Bridge failure (Italy, 2018)—show how nations integrate digital monitoring, public accountability, and long-term rehabilitation frameworks.

This study revisits Indian bridge collapse cases through the lens of **risk management**, **technological feasibility**, and **policy reform**.

Case Studies: Taratala (Majerhat) Flyover Collapse, Kolkata (2018) & Gambhira Bridge Collapse, Gujarat (2025) and 2 more examples

1. Ultadanga Flyover, Kolkata (2013)

- **Case:** Curved steel span collapsed after truck hit barrier.
- **Cause:** Missing/failed bearings & arrestors.
- **Lesson:** Critical detailing & continuous monitoring essential.

2. Talkies Flyover, Kolkata (2016)

- **Case:** Collapse during construction, >100 dead.
- **Cause:** Weak temporary works + poor contractor scrutiny.
- **Lesson:** Temporary works need equal scrutiny; cost-cutting undermines safety.

3. Taratala (Majerhat) Flyover, Kolkata (2018)

- **Case:** 40-year-old PSC flyover span collapsed, 3 dead, 20+ injured.
- **Cause:** Ageing, corrosion, overloading, metro works impact.
- **Lesson:** SHM, audits, preventive maintenance, independent safety authority.

4. Gambhira Bridge, Gujarat (2025)

- **Case**: 830 m RCC bridge span collapsed, ~20 dead.
- **Cause:** Ageing, heavy loads, poor maintenance, failed repairs.
- **Lesson**: Prioritize old bridges; NDT, SHM, axle-load enforcement, public condition ratings.

Table 1. Comparative Summary of Causes and Lessons:

Case	**Cause(s)**	**Key Lesson(s)**
Ultadanga Flyover, Kolkata (2013)	Lack of uplift/tension bearings and seismic arrestors; failure under minimum load	Critical detailing of supports; preventive measures even at low loads
Talkies Flyover, Kolkata (2016)	Poor design of temporary works; inadequate contractor scrutiny; cost-driven compromises	Temporary works need equal importance; strengthen contractor evaluation; applied engineering education
Taratala Flyover, Kolkata (2018)	Ageing, corrosion, overloading, weak maintenance, nearby metro stresses	SHM systems, regular audits, load management, and creation of Bridge Safety Authority
Gambhira Bridge, Gujarat (2025)	Ageing, heavy vehicular loads, poor maintenance, no real-time monitoring, weak inspections	Prioritize old bridges; SHM & NDT inspections; axle-load enforcement; public disclosure of condition ratings

A. Comparative Case Study: Majerhat Flyover Collapse (Kolkata, 2018) vs. Gambhira Bridge Collapse (Gujarat, 2025)

Table 2. Event Profiles

Attribute	**Majerhat (2018)**	**Gambhira (2025)**
Location	Kolkata	Vadodara

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Type	PSC Flyover	RCC River Bridge
Commissioned	1978	1985
Age	40 yrs.	40 yrs.
Casualties	3 dead, 20+ injured	~20 dead
Trigger	Metro excavation impact	Slab fatigue & overloading
Aftermath	Cable-stayed replacement	State-wide audits, safety authority proposal

Similarities: Ageing, poor maintenance, overloading, no SHM, inspection gaps, peak-hour collapse.

Differences: Urban vs regional role, different triggers, casualty scale, govt. response.

Table 3. Lessons Learned:

Aspect	Majerhat Flyover (2018)	Gujarat Bridge (2025)	Key Lessons
Age & Condition	~40 years old, ageing structure	~50 years old, fatigue-prone	Older bridges need retrofitting & periodic structural audits
Triggering Factors	Metro construction vibration, possible design detailing weakness	Heavy freight load, slab fatigue between piers	External stresses + overloading can accelerate failure
Monitoring & Maintenance	Minimal SHM, inadequate NDT inspections	No advanced monitoring, limited preventive checks	Structural Health Monitoring (SHM) + scheduled NDT is essential
Immediate Impact	Partial span collapse, vehicles crushed, casualties	Deck slab collapse, casualties & major traffic disruption	Urban flyovers & freight corridors need redundant evacuation routes
Disaster Response	Rescue hampered by congested area	Rescue delayed by access issues	Pre-planned Disaster Response SOPs improve efficiency
Post-Incident Actions	Probe committees, construction review, increased checks ordered	Govt. ordered state-wide bridge safety audit	Regular state/national bridge safety audits must be institutionalized

Policy & Governance Lessons

- Independent Bridge Safety Authority.
- Mandatory audits every 5 years (>30 yr. bridges).
- Public health scorecards.
- Digital twins & IoT sensors for SHM.
- Legal accountability for negligence.

Table 4. Differences;

Aspect	Majerhat (2018)	Gambhira (2025)
Urban vs. Regional	Urban flyover in dense city traffic	River bridge connecting districts
Triggering Factor	Possibly aggravated by metro excavation & vibrations	Progressive slab failure between piers
Casualties	Lower (~3) due to partial failure	Higher (~20) due to multiple vehicles plunging into river
Post-Collapse Response	New cable-stayed bridge constructed	Massive state-wide audit & bridge closures
Govt Action	Local probe, expert committee	Suspension of engineers, proposal for Asset Safety Authority

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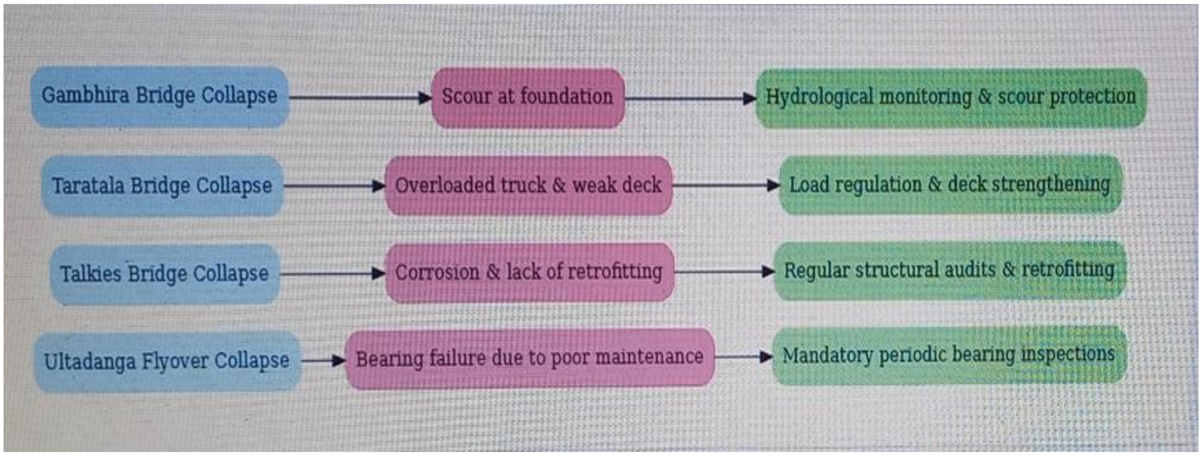

Figure 1. Four Bridges Collapse Flow

Table 5. Comparative Disaster Management Response:

Step	Majerhat (2018)	Gambhira (2025)
Immediate Rescue	NDRF, fire services, cranes	NDRF, divers, heavy equipment
Traffic Diversion	Alternate road corridors, ferry expansion	Closure of adjacent bridges, major diversions
Communication	City govt briefings	State-level emergency alerts
Follow-up	Reconstruction project	Bridge audits, policy proposals

II. Methodology for Disaster Management in Bridge Collapse

The study follows a comparative case-study approach, using both primary data (inspection reports, eyewitness accounts, structural drawings) and secondary literature (government inquiries, peer-reviewed papers, and news archives).

Disaster management for bridge collapse follows the cycle of Preparedness, Response, Recovery, and Mitigation.

a. Preparedness: Maintain a digital bridge database with inspection records, pre-map diversion routes using GIS, train rapid response teams, and stockpile emergency equipment (Bailey bridges, cranes, cutters).

b. Immediate Response: Deploy NDRF, police, and medical teams for rescue; activate traffic diversions; provide real-time public advisories; and secure the collapse zone.

c. Recovery: Clear debris, restore traffic temporarily, begin repair/reconstruction after audits, and support victims' families.

d. Mitigation: Adopt SHM sensors, NDT-based inspections, independent audits every 5 years, and strict load regulation.

e. Alternative Routes (Taratala Experience): Post-collapse, traffic was diverted via Diamond Harbour–Durgapur Bridge–Alipore and Prince Anwar Shah Connector, while suburban rail and metro works were expedited. Future plans must use GIS-based dynamic rerouting.

f. Future Corrective Measures: Digital twins, IoT-based SHM, centralized Bridge Management Systems, tiered inspection regimes, dedicated maintenance budgets, and community reporting mechanisms.

Standard Operating Procedure (SOP)

- **Alert & Activation –** Report incident, mobilize emergency services.
- **Rescue & Evacuation –** Cordon zone, triage, hospitalize injured**.**
- **Traffic Management –** Implement diversions, strengthen public transport.
- **Public Communication –** Press, media, helplines for updates.
- **Site Safety & Recovery –** Secure structure, remove debris, start safe reconstruction.
- **Post-Disaster Audit –** Engineering study, publish findings, update BMS.

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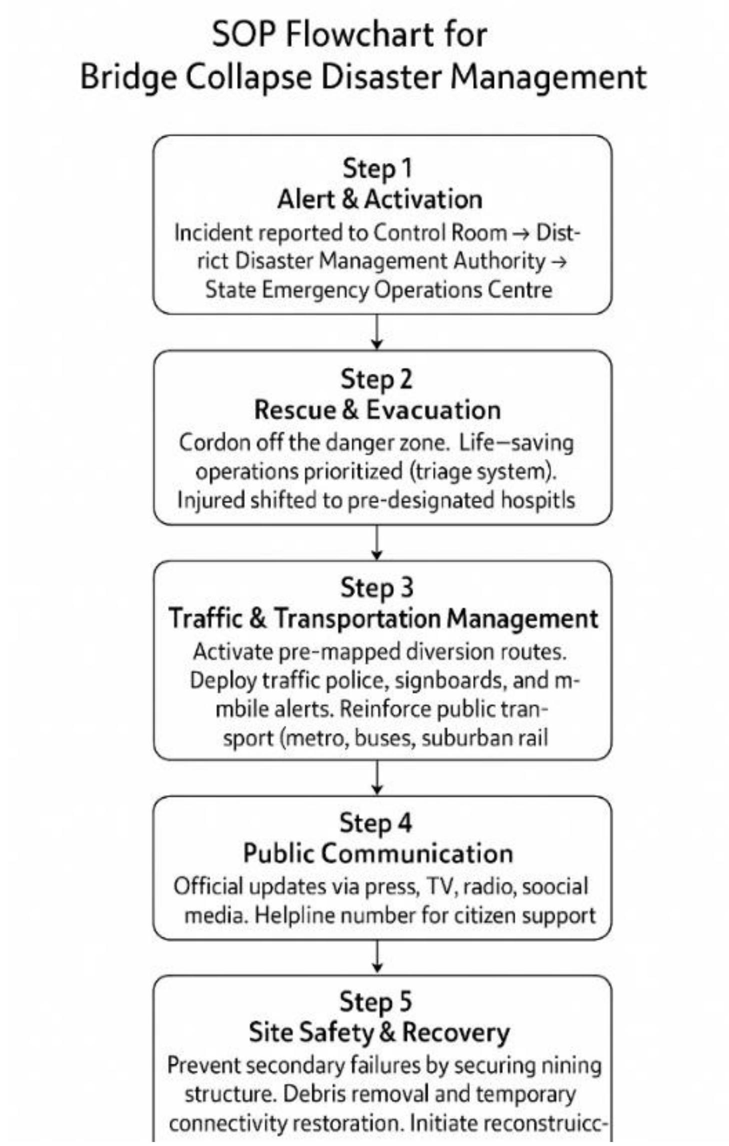

Fig 2. SOP Flowchart: Bridge Collapse Disaster Management

SOP – Bridge Health Monitoring

a. Objective:

Ensure bridge safety, serviceability, and durability through systematic inspection, testing, and monitoring.

b. Methodology

- **Routine Inspection –** Visual checks every 6 months.
- **Detailed Inspection** – NDT every 3–5 years.
- **Continuous SHM –** Sensors + digital models for critical bridges.
- **Data Management –** Digital reports, condition ratings, predictive planning.

c. Steps

1. **Baseline Data** – Bridge inventory & condition report.
2. **Routine Inspection –** Cracks, corrosion, settlement, spalling.
3. **Detailed Inspection –** NDT tools (UPV, GPR, rebound hammer, load testing).
4. **SHM –** IoT sensors (vibration, strain, tilt, corrosion, weather).
5. **Risk Assessment –** Condition index (Good/Fair/Poor/Critical).

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6. **Maintenance –** Preventive, corrective, or rehabilitation works.
7. **Reporting –** Digital Bridge Health Reports on central portal.

d. Implementation

- **Agencies:** PWD / Bridge Division / Local Bodies.
- **Execution:**
  - **Year 1 –** Baseline survey, training, equipment setup.
  - **Year 2+ –** Inspections & SHM.
- **Audit:** Third-party every 5 years + public dashboard.

Challenges & Solutions

- **Manpower gap** → Training.
- **Budget limits** → Prioritize critical bridges.
- **Rehab delays** → Dedicated annual funds.

Key Instruments in the System

- **Strain Gauges** → monitor stress in bridge members.
- **Accelerometers** → detect vibrations, seismic effects.
- **Displacement/Deflection Sensors (LVDTs, GPS)** → track deck movement.
- **Tilt/Inclinometers** → measure angular tilt of piers/deck.
- **Vibration Sensors (geophones, velocity pickups)** → dynamic response.
- **Temperature & Humidity Sensors** → for environmental effects.
- **Corrosion Sensors** → rebar deterioration monitoring.
- **Data Logger + Wireless Gateway** → collects and transmits data.
- **Clod/SCADA/Control Centre** → storage, processing, alerting.

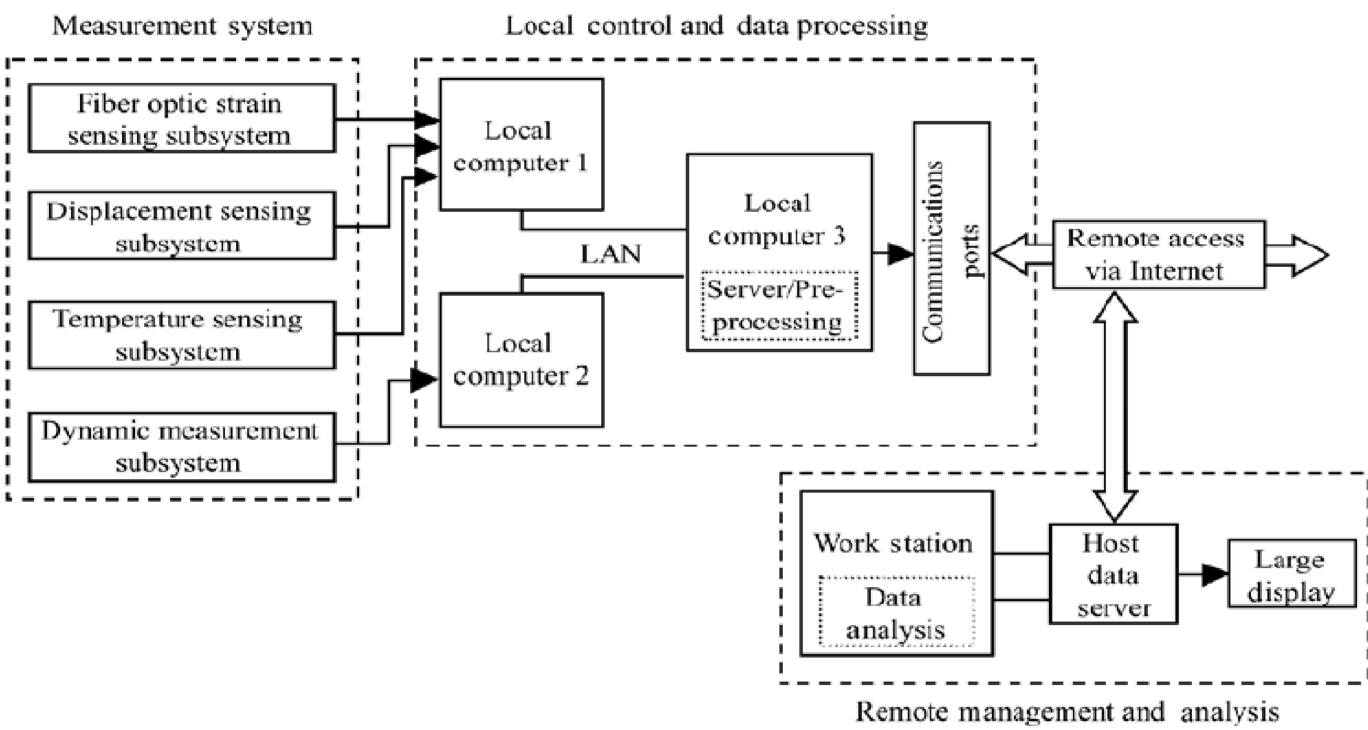

Figure 3. Schematic Diagram of Bridge Health Monitoring System

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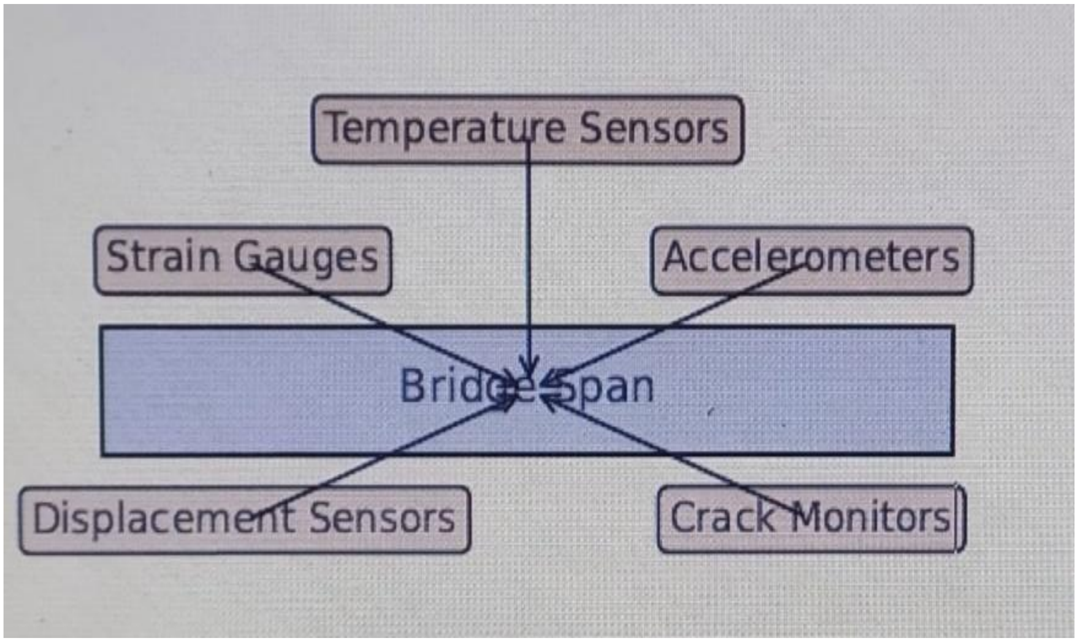

Standard Sample Forms for Implementation

Form A – Routine Visual Inspection Checklist

Item	Observation	Severity (Low/Med/High)	Action Required	Photo Ref.
Deck cracks	3 longitudinal cracks (5 mm)	Medium	Epoxy injection	IMG-23
Bearing condition	Rust at bearing seat	High	Replacement	IMG-45
Drainage system	Blocked at pier P2	Low	Cleaning	IMG-56

Form B – Detailed Inspection & NDT Record

Test Type	Location	Result	Standard Limit	Interpretation
Rebound Hammer	Deck @ span 2	Avg. 28	>30	Slight deterioration
UPV	Girder G3	3.2 km/s	>3.5 km/s	Honeycombing suspected
Half-Cell Potential	Pier cap P1	-400 mV	<-350 mV → Active corrosion	Corrosion present

Form C – Bridge Condition Rating (BCR)

Component	Rating (1–5)	Remarks
Deck slab	3	Cracks present, needs sealing
Bearings	2	Severe rusting, replacement urgent
Piers	4	Good condition
Expansion joints	3	Leakage observed

(Rating Scale: 1 = Critical, 2 = Poor, 3 = Fair, 4 = Good, 5 = Excellent)

Form D – SHM Monitoring Data (Automatic Log)

Sensor ID	Parameter	Reading	Threshold	Status
ACC-01	Vibration Frequency	12.5 Hz	12–14 Hz	Normal
STR-05	Strain	650 με	<700 με	Safe
COR-02	Corrosion potential	-380 mV	<-350 mV	Warning

a. Implementation & Execution Flow

1. Routine Inspection (Field Engineers) → Fill Form A, submit with photos.
2. NDT & Detailed Testing (Experts) → Fill Form B, generate BCR (Form C).
3. Critical Bridges → Install SHM Sensors → Automatic data logged in Form D.
4. Central Bridge Management System (BMS):
   - Stores all forms digitally.
   - Auto-generates maintenance priority list.

b. Execution:

- Maintenance team executes preventive/corrective works.
- Reports updated in BMS for audit.

III. Discussion & Conclusion

Bridge failures arise from a chain of weaknesses—design flaws, poor execution, inadequate maintenance, and systemic gaps. Beyond technical lapses, bureaucracy, political pressure, lack of transparency, and lowest-cost tendering practices further erode quality.

The case studies highlight recurring issues: ageing structures, neglected maintenance, and overuse. Preventive audits, structural health monitoring, strict load control, and institutional accountability are critical. A National Bridge Safety Program is urgently needed, with real-time monitoring, standardized inspections, predictive maintenance, and clear accountability.

Bridge safety in India demands a transition from reactive maintenance to predictive resilience. Lessons from Majerhat and Gambhira cases underscore the importance of combining engineering diagnostics with institutional accountability. Adoption of IoT, SHM, and Digital Twin systems, supported by enforceable policy frameworks and transparent governance, can transform India's bridge infrastructure into a resilient, monitored, and citizen-safe network

IV. Recommendations

Key measures include mandatory BHM, independent Bridge Safety Authority, transparent audits, funding mechanisms, and integration with Smart City GIS platforms. Comparative adoption of global protocols like FHWA-NBI (USA) and Inspection Code for Highway Bridges (Japan) is suggested.

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